Department of Social Research
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Finland

EDUCATION AND FERTILITY

A STUDY ON PATTERNS AND MECHANISMS AMONG MEN AND WOMEN IN FINLAND

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ACADEMIC DISSERTATION

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ABSTRACT

Educational differences in fertility have attracted wide interest in the scholarly literature and beyond. The topic is important because such differences signal differences between social groups in a crucial aspect of wellbeing: family life. The difficulty in combining an educational and professional career with motherhood is an acknowledged concern. Men's fertility overall, differences between social groups, and the reasons behind and the consequences of such differences have received less attention in the research literature. Associations between education and fertility on the individual level are widely documented in women, but the mechanisms behind the associations are still not entirely clear. The literature thus far concentrates mainly on women, although a stronger interest in men has become evident in recent decades.

The main focus of this study is on lifetime fertility, understood as the total number of children, the chance of having a first child, and the number of children after the first child. The aims were both descriptive and analytical. On the descriptive level the emphasis is on men's fertility according to age, educational group and parity. On a more analytical level, the study assesses the extent to which educational differences in lifetime fertility are attributable to early-life characteristics or mediated by characteristics in adulthood. A further aim was to investigate the extent to which the association between education and the chance of having a first child is attributable to underlying genetic or environmental factors.

The study is based on two data sets. The set used in three of the four sub-studies comprised a 10-per-cent sample of households in the 1950 Census in Finland. The cohorts under investigation covered women and men born between 1940 and 1950, who could be linked to later register-based information including education and fertility records. This data allowed the identification of siblings. The data used in the fourth sub-study was based on the older cohort of the Finnish Twin Cohort Study, covering cohorts born between 1950 and 1957. Information on education was survey-based, and fertility was linked from the registers. Monozygotic and dizygotic twins were identifiable in this data set. The methods used included descriptive analysis (age-specific fertility rate, interquartile range, decomposition by parity), logistic and Poisson regression analysis, sibling fixed-effects regression analysis based on conditional models, and behavioural genetics analysis based on Cholesky decomposition.

Women educated to higher levels accumulated fewer children, and men respectively more children, in their lifetime. A weak U-shaped association was found between education and fertility of higher parities among both women and men. The positive gradient in the number of children among the men was largely attributable to first births and to a smaller extent to second births. Educational differences in age-specific fertility in the teens and early 20s were

much larger among the women than the men. Fertility varied more in terms of timing and parity among men with a low level of education. A less-well-off family background predicted higher fertility in women but lower fertility in men. Neither observed early-life characteristics nor unobserved characteristics shared by same-sex siblings explained the educational differences in men's lifetime fertility, and had a moderate explanatory role among the women. Among the men, occupational position and income considerably mediated the chance of having a first child. Further, the association between education and the chance of having a first child was modelled as a genetic correlation in the behavioural genetics analysis. The implication is that the same genetic factors may influence fertility indirectly through education, or/and influence both education and fertility directly.

Men and women differed more in terms of having a first child and young-age fertility than in fertility in the case of higher parities and at older ages. Further, these differences contributed considerably to the gender difference in lifetime fertility by educational group. The moderate explanatory role of early characteristics in women and the lack of such a role in men indicate that adulthood mechanisms are likely to be more influential in explaining the association. Given the results as a whole, the plausibility of indirect genetic effects through education on the chance of having a first child is noted. Among men, economic mechanisms may be more influential in explaining educational differences in the chance of having a first child than in fertility beyond that. Relatively common childlessness among less-highly-educated men may contribute to further differences in wellbeing between population sub-groups.

ABSTRAKTI

Koulutuksen mukaiset erot hedelmällisyydet ovat olleet laajan kiinnostuksen kohteena jo pitkään. Aihe on tärkeä, sillä nämä erot ilmentävät osaltaan sosiaalisten ryhmien välisiä eroja keskeisellä hyvinvoinnin osa-alueella: perhe-elämässä. Pitkän kouluttautumisen ja työuran yhteensovittaminen äitiyden kanssa on tunnustettu huolenaihe. Vähemmän on tarkasteltu miesten hedelmällisyyttä, sosiaaliryhmien välisiä eroja miesten hedelmällisyydessä, sekä näiden erojen taustalla vaikuttavia tekijöitä ja seurauksia. Vaikka koulutuksen mukaisia eroja on dokumentoitu ja tutkittu laajasti naisilla, taustalla olevia mekanismeja ei voida edelleenkään pitää täysin selviä. Aiempi kirjallisuus on painottunut naisia koskeviin tutkimuksiin, mutta miehiin kohdistuva kiinnostus ja heitä koskeva tutkimustieto on lisääntynyt viimeisten vuosikymmenien aikana.

Tämän tutkimuksen pääpaino oli elinikäisen hedelmällisyyden tutkimisessa. Elinikäinen hedelmällisyys määriteltiin kaikkien lasten lukumääränä, ensimmäisen lapsen saamisen todennäköisyytenä, ja lasten lukumääränä ensimmäisen lapsen jälkeen. Tutkimuksella oli sekä kuvailevia että analyyttisempiä tavoitteita. Kuvailevalla tasolla tarkasteltiin erityisesti miesten hedelmällisyyttä ikä- ja koulutusryhmän sekä pariteetin mukaan. Analyyttisemmin pyrittiin selvittämään ensinnäkin sitä, missä määrin havaitut varhaiset sosioekonomiset ja -demografiset tekijät tai muut sisarusten jakamat tekijät selittävät koulutuksen mukaisia eroja elinikäisessä hedelmällisyydessä naisilla tai miehillä. Toisekseen tarkasteltiin miesten osalta sitä, missä määrin aikuisiän sosioekonominen asema ja tulot välittävät kyseistä yhteyttä. Lisäksi pyrkimyksenä oli selvittää, missä määrin koulutuksen ja ensimmäisen lapsen saamisen välisen yhteyden taustalla on yhteisiä geneettisiä tai ympäristötekijöitä.

Tutkimus perustui kahteen tilastoaineistoon. Kolmessa neljästä osatyöstä käytettiin vuoden 1950 väestölaskentaan perustuvaa 10 prosentin otosta kotitalouksista. Analysoitava otos koostui vuosien 1940 ja 1950 välillä syntyneistä nais- ja mieskohorteista, jotka voitiin yhdistää myöhempiin rekisteritietoihin, mukaan lukien koulutusta ja hedelmällisyyttä koskevia tietoja. Aineisto mahdollisti ei-takautuvan mittauksen lapsuuden oloista sekä sisarusten tunnistamisen. Neljännessä osatyössä käytettiin vanhempaan suomalaiseen kaksoskohorttiin perustuvaa otosta vuosien 1950 ja 1957 välillä syntyneistä nais- ja miespuolisista kaksosista. Tieto koulutuksesta perustui kyselytutkimukseen ja hedelmällisyys vastaavasti rekistereihin. Aineistossa voitiin tunnistaa identtiset ja epäidenttiset kaksosparit. Tutkimuksen menetelmiin lukeutuivat kuvailevat menetelmät (ikäryhmittäinen hedelmällisyysluku, kvartiilivälin pituus ja pariteetin mukainen dekomponointi), logistinen ja Poisson regressioanalyysi, sisarusten kiinteiden

vaikutusten regressioanalyysi perustuen ehdollisiin malleihin, ja käyttäytymisgeneettinen analyysi perustuen Choleskyn hajotelmaan.

Korkeammin koulutetuille naisille syntyi vähemmän ja miehille vastaavasti enemmän lapsia. Elinikäisessä lasten lukumäärässä ensimmäisen lapsen jälkeen havaittiin heikko U-muotoinen yhteys koulutusryhmän mukaan tarkasteluna naisilla ja miehillä. Miehillä positiivinen yhteys koulutuksen ja lasten lukumäärän välillä oli valtaosin seurausta ensimmäisen, ja pienemmässä määrin toisen, lapsen saamisesta. Koulutuksen mukaiset erot ikäryhmittäisessä hedelmällisyydessä olivat suurempia naisilla kuin miehillä nuorissa ikäryhmissä. Miehillä sekä hedelmällisyyden ajoitus että määrä oli vaihtelevampaa vähän koulutettujen ryhmässä. Huono-osainen perhetausta ennusti suurempaa lasten lukumäärää naisilla ja vastaavasti pienempää lukumäärää miehillä. Havaitut varhaiset tekijät tai ei-havaitut sisarusten jakamat tekijät eivät selittäneet koulutuksen mukaisia eroja elinikäisessä hedelmällisyydessä miehillä ja selittivät vain osan eroista naisilla. Aikuisiän ammatillinen asema ja tulot välittivät valtaosan eroista koulutuksen ja ensimmäisen lapsen saamisen välillä miehillä. Käyttäytymisgeneettisen analyysin perusteella koulutuksen ja ensimmäisen lapsen saamisen taustalla on yhteisiä geneettisiä tekijöitä. Tämä tarkoittaa sitä, että samat geneettiset tekijät voivat vaikuttaa hedelmällisyyteen epäsuorasti koulutuksen kautta tai/ja suoraan sekä koulutukseen että hedelmällisyyteen.

Naiset ja miehet erosivat toisistaan eniten ensimmäisen lapsen hankinnan ja nuoren iän hedelmällisyyden suhteen. Nämä tekijät pitkälti johtivat eroon sukupuolten välillä elinikäisessä lasten lukumäärässä koulutusryhmän mukaan tarkasteltuna. Varhaisten tekijöiden rajallinen rooli koulutusryhmien välisten erojen selittäjinä kuvastaa sitä, että mekanismit aikuisiällä ovat todennäköisesti tärkeämpiä erojen selittäjiä. Tutkimuksen tulosten valossa näyttäisi mahdolliselta, että geneettiset tekijät voivat vaikuttaa ensimmäisen lapsen saamisen todennäköisyyteen koulutuksen kautta. Miehillä taloudelliset tekijät näyttäisivät olevan tärkeämpiä selittäjiä koulutuksen mukaisille eroille ensimmäisen lapsen saamisessa kuin hedelmällisyydessä sen jälkeen. Yleisempi lapsettomuus matalasti koulutetuilla miehillä voi kasvattaa hyvinvointieroja väestöryhmien välillä.

CONTENTS

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications:

I	Nisén, J, P Martikainen, K Silventoinen, M Myrskylä. 2014. Age-specific fertility by educational level in the Finnish male cohort born 1940-1950. *Demographic Research, 31*(5):119-136. doi:10.4054/DemRes.2014.31.5
II	Nisén, J, M Myrskylä, K Silventoinen, P Martikainen. 2014. Effect of family background on the educational gradient in lifetime fertility of Finnish women born in 1940-50. *Population Studies, 68*(3):321-337. doi:10.1080/00324728.2014.913807
III	Nisén, J, P Martikainen, M Myrskylä, K Silventoinen. Education, other socioeconomic characteristics across the life course and fertility among Finnish men. Submitted.
IV	Nisén, J, P Martikainen, J Kaprio, K Silventoinen. 2013. Educational differences in fertility: behavioral genetic study of Finnish female and male twins. *Demography, 50*(4):1399-420. doi:10.1007/s13524-012-0186-9

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ABBREVIATIONS

a^2	Genetic Component
AFB	Age at the Birth of the First Child
AIC	Akaike Information Criterion
ASFR	Age-Specific Fertility Rate
c^2	Common Environmental Component
CI	Confidence Interval
DZ	Dizygotic
e^2	Unique Environmental Component
FE	Fixed-Effects
IRR	Incidence Rate Ratio
MZ	Monozygotic
OR	Odds Ratio
r_a	Genetic Correlation
r_c	Common Environmental Correlation
r_e	Unique Environmental Correlation
RRR	Relative Risk Ratio
ρ	Tetrachoric Correlation

1 INTRODUCTION

Differences between educational groups are among the most heavily studied topics in fertility research (Balbo, Billari, & Mills, 2013), motivated in part by changes in period and cohort fertility, and by the rising educational level of women and their changing position in the labour market (Oppenheimer, 1994; Rindfuss, Morgan, & Offutt, 1996). Large educational-group differences in the fertility behaviour of women appear to signal difficulties in combining educational and professional careers with motherhood (Blossfeld, 1995; Lappegård & Rønsen, 2005). The Nordic countries nowadays could be considered a supportive environment for combining employment with childbearing, which is likely to be reflected in the comparatively small, or more positive than elsewhere, educational differences in the quantum and tempo of female fertility (Andersson et al., 2009; Neyer & Hoem, 2008; Rendall et al., 2005; Rendall et al., 2010; Rønsen & Skrede, 2010; Wood et al., 2014).

The postponement of parenthood became a dominant trend across Europe and other Western countries during the second half of the 20th century (Gustafsson & Kalwij, 2006a; Rindfuss et al., 1996), tending to level off at the turn of the millennium and thereafter (Goldstein, Sobotka, & Jasilioniene, 2009; Sobotka, 2004). The rising educational level, especially of women, is considered a major factor behind this trend, in that a larger proportion of the population spend more of their youth and early adulthood in education (Mills et al., 2011; Ní Bhrolcháin & Beaujouan, 2012). For instance, the percentage proportions of Finns aged 24-34 educated to the tertiary level were 18 in 1970, 29 in 1990 and 37 in 2010 (Repo, 2012). At the same time, the age at which women had their first child began rising in the early 1970s from 24.4 years in 1970 to 26.8 in 1990 and 28.3 in 2010 (Gissler, Klemetti, Lammi-Taskula, & Miettinen, 2009; Statistics Finland, 2015).

Highly educated women in the Nordic countries postpone their fertility the longest across the cohorts, but catch up at higher ages to the extent that the differences in lifetime fertility in more recent birth cohorts are not large (Andersson et al., 2009; Rønsen & Skrede, 2010). Educational differences in the lifetime number of children or childlessness among women in the Nordic countries are modest or have narrowed (Andersson et al., 2009). In Finland, for instance, the difference between women educated to the basic and the tertiary level amounted to around 0.4 children among those born in 1940-41, whereas it was around 0.2 among those born in 1960-61, and even less for those born in the intervening period (Ruokolainen & Notkola, 2007). Overall, comparatively strong fertility recuperation, in other words catching up at higher ages on births that were not realised at younger ages, weakens the link between the quantum and tempo of fertility and contributes to relatively high fertility levels in Northern Europe (Andersson et al., 2009; Frejka & Calot, 2001; Sobotka, 2004).

Men have traditionally attracted little attention in discussions on fertility differentials dominated by work-family conflict among women (Forste, 2002), or in family demography more generally (Oppenheimer, 1994). Recently, however, they have featured increasingly in fertility research as partners and as interesting in themselves (Bledsoe, Guyer, & Lerner, 2000; Lappegård, Rønsen, & Skrede, 2011). The changing role of men and fathers, but not in contrast to the changing role of women, may have fuelled this change (Goldscheider & Kaufman, 1996). Men are increasingly involved in the home sphere nowadays than in the past, and therefore their role in fertility decision-making among couples, and in fertility in general, is not likely to decrease (Goldscheider, Bernhardt, & Lappegård, 2015). The starting point in studying educational differentials in male fertility may differ from the traditional assumption that low fertility is characteristic of the well-educated and career-oriented in particular. Male childlessness is more common among the less highly educated in many European countries (Miettinen et al., 2015). Of the men born in Finland in the early 1960s and educated to the basic level, a third were childless at the age of 40-44 (Väestöntutkimuslaitos, 2015).

Previous research on the association between education and fertility behaviour has purported to explain in detail the causes of these relations on the individual and societal level (Gustafsson & Kalwij, 2006b). Various study designs have been used to trace the causes of the patterns on the individual level, including quasi-experimental designs based on changes in compulsory schooling laws (e.g. Monstad, Propper, & Salvanes, 2008), as well as sibling and twin models (e.g. Amin & Behrman, 2014). Researchers focusing on the life-course framework, in turn, have called for more studies on early-life-course predictors of behaviour, addressing questions such as the extent to which early-life circumstances shape patterns that develop in adulthood (Huinink & Feldhaus, 2009; Mayer, 2009). This may also be relevant to the study domain focusing on the associations between education and fertility. Moreover, the discussion on educational differences in fertility also has a methodological element given the accumulating knowledge, the complexity of the relations, and the difficulty of identifying causal mechanisms (Hoem & Kreyenfeld, 2006; Kravdal, 2007).

The objective of this study is to contribute to the existing body of literature in both descriptive and more analytical terms. The research builds on the possibility to utilise high-quality Finnish family and twin data sets covering female and male cohorts born in the 1940s and 1950s. The first aim is to describe less-well-known patterns of educational differences in male fertility by age group and parity, and to document the association of education and early-life characteristics with lifetime fertility in Finland. A further aim is to exploit the available detailed socioeconomic and other early-life information to analyse the extent to which these characteristics explain some of the association between education and lifetime fertility. Third, same-sex siblings are compared to test for associations within families whose members are more similar to each other than individuals from different families. Finally, data from the Finnish twin registry is used to assess the extent to which the association between education and the chance of having a first child is attributable to underlying genetic or environmental sources of variance.

The concept of fertility in this study refers to the demographic process in which “living members of a population produce live births” (Preston, Heuveline, & Guillot, 2000). The focus is on the quantum of fertility from the perspective of male and female cohorts. The concept of lifetime fertility applied incorporates three outcomes: the number of children ever born as the main outcome, and the chance of having a first child in contrast to that of staying childless, and the number of children beyond the first child as secondary outcomes. The idea is to identify potential parity-specific differences. Fertility timing with respect to the first and subsequent births is assessed in some parts of the study. As a concept, parity typically refers to the number of live births women experience (Preston et al., 2000). Parity progression then refers to the movement of a woman from one parity level to the next, for instance from being childless to having one child. The concept of parity in this study applies to men and women alike.

The study includes previous empirical evidence from Western countries, including Europe, the United States and Australia. Little attention is paid to Eastern Europe given its particular societal development and the implications for fertility behaviour (Sobotka, 2004; Wood, Neels, & Kil, 2014). It has been suggested that the Nordic countries constitute a Nordic fertility regime (Andersson et al., 2009; Frejka & Calot, 2001). The term refers to similarities between the Nordic countries in fertility levels and social differences therein, often addressed to similarities in national socio-cultural contexts and welfare-state policies. The results of the study are therefore discussed in the light of previous studies from the Nordic countries.

2 A REVIEW OF THE LITERATURE

2.1 CONCEPTUAL FRAMEWORK

2.1.1 EDUCATION AND FERTILITY IN THE LIFE COURSE

Given the aim in this thesis to enhance understanding of the interrelationships between education and lifetime fertility, the life-course perspective is adopted as the overall conceptual framework. The life course as a concept refers to age-dependent life configurations, which are regulated by social institutions and are susceptible to historical change (Elder, 1992; Elder, 1994; Giele & Elder, 1998). In other words, individual experiences are always both individually and socially determined. The overall life-course framework is complemented with more specific ideas on how education and fertility may be related. This approach is recommended in previous literature with respect to research on families and fertility (Buhr & Huinink, 2014; Huinink & Feldhaus, 2009; Huinink & Kohli, 2014).

Age is a critical dimension in the study of fertility given the age-related decrease in fecundity that constrains childbearing among women in particular (Mills et al., 2011; Schmidt et al., 2012)[1]. For instance, it has been estimated that 75 per cent of women who start trying to conceive at the age of 30 under natural conditions will have a conception ending in a live birth within one year, whereas the respective proportion reduces to 66 per cent at the age of 35 and 44 per cent at 40 (Leridon, 2004). Men may be indirectly affected by their partner's age, but a parental age of over 40 also appears to be an independent risk factor among couples for experiencing difficulties in having a baby (De la Rochebrochard & Thonneau, 2003; de La Rochebrochard et al., 2006). Moreover, women may be more constrained by age-related social perceptions concerning the right timing of parenthood (Billari et al., 2011).

The life course is embedded in a multilevel structure consisting of external and internal conditions (Elder, 1994; Huinink & Kohli, 2014). External conditions involve influences on the societal level on the one hand, and on the level of the individual's social context and networks on the other. Internal conditions refer to individual personal and physiological factors. For instance, gender, a crucial aspect of fertility behaviour (Goldscheider et al. 2015; Keizer, Dykstra, & Jansen, 2008), could be considered an internal condition (sex) even if its role is also crucially influenced by external conditions such as social norms. Individual action and social structure also influence each other reciprocally (Huinink & Feldhaus, 2009).

[1] Fecundity refers to the biological component of fertility, i.e. the capacity to produce a live birth (Preston et al., 2000). This consists of the ability to conceive, the rate of pregnancy loss, and the probability of permanent inability to conceive (Leridon & Slama, 2008).

The individual life course is influenced by interdependencies between various life domains such as education, work and family (Elder, 1992; Elder, 1994; Huinink & Kohli, 2014), and is characterised by transitions such as forming a co-residential union or entering parenthood. Given the dependency between different life domains, a transition in one life sphere may have consequences for transitions in others. These transitions may involve several phases and decision-making steps (Elder, 1992). It is often emphasised that staying childless should be understood in relation to developments in other areas of life, for example (Dykstra & Wagner, 2007; Hagestad & Call, 2007). Furthermore, interdependence between past, present and future influences individual lives (Elder, 1994; Huinink & Kohli, 2014), and it is assumed that past experiences and anticipation of future life events affect current decision-making. Future expectations are likely to have a strong influence on fertility-related decision-making in that having a child implies a particularly heavy and long-term commitment (Huinink & Kohli, 2014).

Interdependency between individuals should also be acknowledged (Elder, 1992; Elder, 1994; Giele & Elder, 1998), which in connection with fertility is obvious given that in most cases having a biological child is inevitably related to having a sexual partner (Mosher & Bachrach, 1982), in particular among men (Keizer et al., 2008). The partnership context may also relate to preferences and intentions concerning childbearing: staying single may indicate low preferences favouring children for some, whereas lacking a partner is an obstacle to having a child for others (Miettinen & Rotkirch, 2008). People may adjust their fertility intentions according to their current life circumstances (Letherby, 2002; Schoen et al., 1999; Toulemon, 1996), and intentions may be less predictive of overall fertility among men (Berrington & Pattaro, 2014). Moreover, not only the presence of a partner, but also his or her characteristics may influence fertility (Jalovaara & Miettinen, 2013). Interdependency may even extend to earlier generations, which may widen and/or constrain individuals' options in life (Elder, 1992).

Overall, the life course is a complex process in which individuals seek subjective wellbeing (Huinink & Feldhaus, 2009). They plan and choose within the constraints and possibilities of their environment to achieve their goals (Elder, 1994; Giele & Elder, 1998). Acquiring education could be described as welfare promotion through investment in human capital (Becker, 1993b). Human capital here refers to the possession of knowledge, skills and abilities to analyse problems. In a similar vein, education could be assumed to enforce agency and control over one's life (Mirowsky & Ross, 2003). It is also a major determinant of one's future position in the labour market and one's income (Elo, 2009; Lynch & Kaplan, 2000). Others argue, however, that it may reflect correlated individual characteristics such as intelligence (Barrett & Depinet, 1991), which are not entirely derived from education as such (see Mirowsky & Ross, 2003). Education reflects the influence of the past at least as a major factor in the transmission of the socioeconomic standing of the previous generation to the next one (Breen & Jonsson, 2005).

According to Huinink & Kohli (2014), fertility also serves as a means of gaining personal welfare: it could be said that children in modern individualised societies "provide a special type of close relationships which are instrumental to improve and sustain the psychological dimension of one's well-being". Although the focus in this study is on the quantum of fertility, it is not only the occurrence but also the timing of events that is relevant from the life-course perspective. It involves adjustment from individuals aiming at the achievement of goals (Elder, 1994; Giele & Elder, 1998). Fertility decisions could be described as consecutive life-course decisions that create variation in the quantum of fertility but also in the timing of the first child and the spacing of subsequent births (Berrington & Pattaro, 2014; Huinink & Kohli, 2014; Kreyenfeld & Konietzka, 2008; Thomson, Winkler-Dworak, & Kennedy, 2013).

Inherent in the life-course perspective are more specific theoretical ideas on the relationship between education and fertility, clustered in three perspectives that need not to be mutually exclusive: (1) ideas imposing an effect of education on fertility; (2) ideas suggesting reverse causality, i.e. an effect of fertility on education; and (3) ideas concerned with the problem of confounding factors, implying that the relationship between education and fertility may be spurious and attributable to third factors preceding both outcomes (see Gustafsson & Kalwij, 2006b; Kravdal, 2007). These notions are based mainly on economic and sociological theories, but there are also influences from more psychologically oriented work, which are discussed in the following sections. Moreover, evolutionary theory has motivated interest in the relationship between status and reproduction in contemporary societies (e.g. Fieder & Huber, 2007). Theoretical insights from this strain of literature are overlooked, but empirical findings that are relevant to the study questions are referred to.

2.1.2 THE EFFECT OF EDUCATION ON FERTILITY

A causal influence of education on fertility may run through several pathways. According to previous research, a distinction should be made between the effects of enrolment in education and attainment (e.g. Kravdal, 2007; Lappegård & Rønsen, 2005). Low fertility during educational enrolment may be attributable to incompatibility between time allocated to studying and parenting, a lack of sufficient financial resources to support a child, or social norms discouraging parenting before finishing education (Blossfeld & Huinink, 1991; Hoem, 1986; Ní Bhrolcháin & Beaujouan, 2012; Thalberg, 2013). A longer enrolment period, in turn, may lead to a lower likelihood of eventual childbirth simply because of the shortening of the potential time period in life when having children is feasible (Lappegård & Rønsen, 2005). In general, the gradual postponement of parenthood is considered a major route to remaining childless, at least for women (Kemkes-Grottenthaler, 2003; Rowland, 2007; Toulemon, 1996). In terms of postponing family formation, longer periods of educational enrolment may result in a higher risk of childlessness in women in particular on account of an age-related decrease in fecundity (Hagestad & Call, 2007; Keizer et al., 2008).

Given that the more highly-educated of both genders leave school later than those with shorter educational-enrolment periods, there may be higher fertility among those with higher attainment net of enrolment given the biological pressure on women in particular to have children before the decrease in fecundity (Kravdal, 2001; Kravdal, 2007). This may be reflected not only in the intensity of having the first child after finishing education, but also in the timing of subsequent children (e.g. Bartus, Murinkó, Szalma, & Szél, 2013; Kreyenfeld, 2002). It is argued in a previous Danish study, however, that this may not be the reason for the higher second-birth rates among highly educated women (Gerster, Keiding, Knudsen, & Strandberg-Larsen, 2007). In addition, it has been suggested that social norms discourage childbearing at higher ages among women in particular (Billari et al., 2011; Rindfuss & Bumpass, 1976). The educational group to which an individual belongs constitutes an influential social reference group with regard to fertility-related decision-making (Rindfuss & Bumpass, 1976). It may guide perceptions of the right timing of parenthood and influence fertility in practice.

Education may have an influence on fertility net of enrolment. The micro-economic framework has been a common starting point among researchers studying relationships between educational attainment and fertility (e.g. Kreyenfeld & Konietzka, 2008). According to the micro-economic approach to family, put forward by Becker (1993a), individuals behave rationally and the demand for children increases at higher income levels. Micro-economic theory implies that higher acquired educational attainment through accumulated human capital leads to higher income levels and better employment prospects in general, and therefore to better chances of providing for a larger family. However the opportunity costs of children also increase at higher income levels through forgone income and experience resulting from reduced working hours, for example, which is assumed to affect fertility negatively (Becker, 1993a). Thus, these two mechanisms, a positive effect of income and a negative effect of opportunity costs, work in opposite directions.

Traditionally, these effects are considered to operate gender-specifically given the specialisation of household tasks between men and women based on small original comparative advantages (Becker, 1993a). In its strictest sense, it was assumed that the utility of the household was maximised when men specialised exclusively in breadwinning and women in homemaking. The specialisation model has been criticised for being too risky as a strategy for maximising household utility (Oppenheimer, 1997). For example, if a household member cannot accomplish his/her task because of an accident or illness, the utility of the household may not be maximised if the allocation of tasks is exclusively specialised relative to alternative strategies. Oppenheimer (1997) suggests an alternative model according to which partners pool their resources and both contribute by providing household income. Hence the economic resources of both the man and the woman enhance their marriage formation. Esping-Andersen (2009) also criticises the model on the grounds that women's stronger economic position increases their bargaining power in the family and not necessarily lowers their gain to marriage.

The specialisation of tasks, at least in the strict sense of the term, is not the current reality in many industrialised countries (Esping-Andersen, 2009; Goldscheider et al., 2015), but the concepts of income effect and opportunity cost are still relevant. The income effect is likely to dominate the opportunity costs among men, at least as long as they are considered the main providers of family income. Even if the expectations on men as caregivers have increased (Joshi, 1998), expectations in terms of breadwinning appear not to be losing ground (Hart, 2015; Ravanera & Beaujot, 2014; Winkler-Dworak & Toulemon, 2007). In contexts such as Finland where the dual-earner model is the norm, however, the income effect on family formation and fertility may also strengthen among women (Jalovaara, 2012; Jalovaara & Miettinen, 2013), thereby also predicting less negative associations between education and fertility (Kravdal & Rindfuss, 2008).

Having children is closely associated with partnership formation, and education may also influence fertility through partnerships (Berrington & Pattaro, 2014; Huinink, 1995; Lappegård & Rønsen, 2013; Liefbroer & Corijn, 1999). Men of higher standing in the labour market, and potentially increasingly also women (Oppenheimer & Lew, 1995), are likely to be more successful in finding partners (Becker, 1993a; Oppenheimer, 1988). What women gain from marriage may not decrease because of their more independent economic position (Oppenheimer, 1994; Oppenheimer, 1997). According to Becker (1993a), "the main purpose of marriage and families is the production and rearing of own children". Consequently, if an adequate economic standing is a prerequisite for having children, then more highly-educated men, and potentially increasingly also women, with higher incomes and better employment prospects are likely to be viewed as more attractive partners and potential parents by the opposite gender, which could thus promote partnership formation and fertility.

From an economic perspective it has also been suggested that interaction between quality and quantity determines the number of children (Becker, 1993a; Becker & Lewis, 1973). This refers to the trade-off between quantity and quality, based on the assumption that higher income levels may not necessarily lead to having more children but rather to having children of higher quality. Hence, quantity may give way to quality and lead to lower fertility among more highly educated couples.

The economic framework outlined above concerning the lifetime number of children has been described as essentially static in not considering the timing and spacing of fertility during the life course of individuals (Gustafsson & Kalwij, 2006b; Hotz, Klerman, & Willis, 1997). More recently, scholars have been increasingly interested in analysing fertility behaviour by means of a dynamic model that accounts for life-cycle differences in fertility decision-making. From this perspective, too, the standard assumption is that male wages promote fertility and female wages suppress it (see Gustafsson, 2001 and the references therein). The question of the optimal timing of motherhood from a career perspective is more controversial. Some argue that highly educated women delay having children due to a decreasing amount of lifetime earnings lost the longer the birth of the first child is postponed. The optimal timing as far as the male partner's earnings are concerned can be assumed at their maximum, which would also imply the delaying of parenthood overall, and among the highly educated in particular.

Factors other than enrolment and economic mechanisms may also link education to fertility. Education may reflect life values and orientations that affect the decision-making (Lesthaeghe, 1983; Van de Kaa, 1996). The loosening of traditional norms and the trend towards individualism may encourage seeking fulfilment in life without children, and the more highly educated may be the first to adopt new cultural ideas in their behaviour. Groups at different educational levels may also differ in their knowledge and practice of contraception, which may affect fertility particularly at young ages (Nelson, 2004). Individuals with varying educational attainment, in turn, may differ in how they plan childbirth, the assumption being that fertility at a very young age tends to be unplanned (Henshaw, 1998) and is more common in lower socioeconomic groups (Kiernan & Diamond, 1983; Vikat, Rimpela, Kosunen, & Rimpela, 2002). Beyond economic incentives, educational attainment may also increase fertility given the propensity to establish more stable partnerships among the more highly educated, attributable to better problem-solving skills or a stronger tendency towards homogamy, for example (Jalovaara, 2012; Lyngstad & Jalovaara, 2010, Mäenpää, 2015).

2.1.3 THE EFFECT OF FERTILITY ON EDUCATION

Alternatively, a causal relationship between education and fertility may go the reverse way, from fertility behaviour to educational attainment (Cohen, Kravdal, & Keilman, 2011; Hoffman, Foster, & Furstenberg, 1993; McElroy, 1996). Higher educational goals may be compromised as a consequence of having children because both parenting and studying are time-consuming and thus potentially competing activities (Dearden, Hale, & Woolley, 1995; Woodward, Fergusson, & Horwood, 2006). As economic factors are likely to contribute to some extent to low fertility during enrolment (Thalberg, 2013), having a child during one's studies may imply an increased need to work to earn money to provide for it, which in turn could inhibit the studying. This may apply particularly in contexts that are not supportive of having children while studying (Billari & Philipov, 2004).

Having a child may affect education, especially if childbearing occurs at an early age (e.g. Morgan & Rindfuss, 1999). Given that a large proportion of teenage births are likely to be unplanned (Henshaw, 1998; Vikat et al., 2002), it could be argued that unplanned rather than planned births at a young age have negative influences on further education. Interference with the educational career is likely to be stronger among women, who mature biologically and tend to have their first children a few years earlier than men (Kiernan & Diamond, 1983; Woodward et al., 2006). Moreover, women's biological and social role in childbearing and early child rearing is more likely to have a negative effect on their education (Dearden et al., 1995; Kiernan & Diamond, 1983; Rijken & Liefbroer, 2009; Sigle-Rushton, 2005; Woodward et al., 2006).

Moreover, the early timing of fertility may affect further fertility through the accumulation of human capital: if childbirth at a young age inhibits the mother from pursuing further educational or occupational achievements, continuing concentration on family life may be more rewarding relative to other opportunities in life (Morgan & Rindfuss, 1999). According to Rindfuss et al. (1980), any preference among women concerning the number of children operates through age at the first birth.

2.1.4 THE PROBLEM OF CONFOUNDING

Education could be considered a strong indicator of human capital, but it is also likely to reflect various other characteristics of importance to fertility (e.g. Skirbekk, Kohler, & Prskawetz, 2006). As discussed in several previous studies, associations between education and fertility are typically believed to reflect causal effects. However, this interpretation has been challenged theoretically and empirically in studies that vary in approach and fertility outcomes on the grounds that education and fertility outcomes may be jointly determined to some extent (see Geronimus & Korenman, 1992; Hoem, Neyer, & Andersson, 2006a; Hoem, Neyer, & Andersson, 2006b; Kravdal, 2007; Martín-García & Baizán, 2006; Monstad et al., 2008; Morgan & Rindfuss, 1999; Rindfuss, Bumpass, & John, 1980; Skirbekk et al., 2006; Tavares, 2010; Upchurch, Lillard, & Panis, 2002). Selection may contribute to the associations if there are other factors directly influencing both education and fertility (Moffitt, 2005). In such a case confounding would be a problem from the point of view of causal interpretation.

According to Hakim (2000), stable individual preferences are more powerful in explaining women's choices in working and family life than economic incentives or cultural and normative factors. Hence, women may be career-oriented or home-oriented, or they may have more flexible attitudes and be more sensitive to the contextual factors in their choices. These three types of women are believed to feature to some extent in all socioeconomic groups, however. This theory could be criticised on the grounds that the values of individuals are sensitive to life-course changes: current circumstances are likely to affect current and future values (Surkyn & Lesthaeghe, 2004). Furthermore, it is not straightforward to distinguish between those who are initially family-oriented and those with limited employment opportunities

(Schleutker, 2014). It has also been suggested that women educated to different levels have varying fertility intentions, education being positively related to such intentions in contemporary Europe (De Wachter & Neels, 2011; Testa, 2014). It is nevertheless challenging to situate and measure the formation of fertility intentions in the life course and thus in a causal framework (see Chapter 2.1.1).

Family background is potentially relevant in terms of influencing the education-fertility association in that factors that are clustered in families of origin may influence preferences and constraints on family life and educational choices from early on (see Axinn, Clarkberg, & Thornton, 1994; Miller, 1994; Miller, 1992; Thornton, 1980). According to Miller (1992, 1994), interaction between genetic predispositions and characteristics of the social environment in childhood and adolescence is, in general, a source of variation in the motivation to have children. Parental educational level and social class could be considered indicators of the wider social and cultural grouping of the family. Life goals other than family building, such as having a career, may be emphasised more strongly in families with a higher parental socioeconomic status (Rijken & Liefbroer, 2009; Scott, 2004), and the potential influence may extend to attitudes and behavioural outcomes in the next generation.

The material circumstances in childhood and youth may influence the consumption aspirations later in life, and this may lead some people to strive for a higher economic standing through education before or instead of having children (Easterlin, 1966; Thornton, 1980). It is also possible that the availability of the material resources of the family of origin to the next generation promotes fertility given the costs associated with children (Goodman & Koupil, 2009). This may apply especially to men if they are assumed to bear more responsibility for providing for their family. Moreover, an advantaged family background may facilitate prolonged schooling through the provision of resources, whereas a less advantaged background may not. Other factors of the family background that correlate with fertility and education and may thus influence the association between the two include sibship size (Murphy & Knudsen, 2002; Pouta et al., 2005), the mothers' fertility preferences (Axinn et al., 1994), and urban versus rural residency (Kulu, Vikat, & Andersson, 2007; Lesthaeghe, 1983).

2.2 EMPIRICAL EVIDENCE

2.2.1 EDUCATION AND THE FIRST PARITY

Previous research shows that acquiring higher levels of education is associated with the postponement of parenthood (Corijn & Klijzing, 2001; Kiernan & Diamond, 1983; Kneale & Joshi, 2008; Liefbroer & Corijn, 1999; Winkler-Dworak & Toulemon, 2007; Zhang, 2011). However, educational differences in age at first birth among women appear to be smaller in magnitude in Northern Europe than in Southern European and Anglo-Saxon countries (Rendall et al., 2005; Rendall et al., 2010). Many studies analysing the transition to parenthood distinguish between the effects of enrolment in education and the level attained net of enrolment.[2] A robust finding is that those who are enrolled have much lower first-birth rates than their same-aged pears who are not studying (see the references below), and the effect of the level is often weaker (e.g. Blossfeld, 1995; González & Jurado-Guerrero, 2006). The effect of enrolment appears to be stronger among women than among men, and at younger as opposed to higher ages (Andersson, 2000; Dribe & Stanfors, 2009; Kravdal, 2007; Thalberg, 2013).[3]

Net of enrolment, studies[4] have shown large variations in the association between the level of education and first-birth rates among women (Billari & Philipov, 2004; Blossfeld & Huinink, 1991; Kravdal, 1994; Kreyenfeld & Konietzka, 2008; Lappegård & Rønsen, 2005; Liefbroer & Corijn, 1999; Martín-García & Baizán, 2006; Martín-García, 2009; Oppermann, 2014; Özcan, Mayer, & Luedicke, 2010; Santow & Bracher, 2001; Tesching, 2012; Vikat, 2004; Winkler-Dworak & Toulemon, 2007) and men (Dribe & Stanfors, 2009; Guzzo & Furstenberg, 2007; Lappegård & Rønsen, 2013; Liefbroer & Corijn, 1999; Martín-García, 2009; Oppermann, 2014; Özcan et al., 2010; Tölke & Diewald, 2003; Winkler-Dworak & Toulemon, 2007). A comparative study reported a negative effect of secondary versus basic education on the first-birth rates of women in several European countries, whereas in only a few cases was such an effect found with regard to tertiary versus secondary education (Billari & Philipov, 2004).

In the case of Finland it was reported in a previous study on labour-market attachment and fertility among women that educational enrolment reduced the first-birth rate (Vikat, 2004). The effect of the level of education varied more: at ages 20-30 the first-birth rate was highest among women with a low

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[2] Several studies also include educational field in their analyses, see e.g. (Hoem et al., 2006a; Hoem et al., 2006b; Lappegård & Rønsen, 2005; Martín-García & Baizán, 2006; Martín-García, 2009; Oppermann, 2014).

[3] According to Dribe and Stanfors (2009), enrolment and parenthood may be becoming less compatible among men and more compatible among women in younger birth cohorts.

[4] These studies differ in the length of the follow-up, however, specifically in the age of the participants at the end of the follow-up, which could have influenced the results.

level of education, whereas at ages 31-44 the more highly educated were at a higher risk of experiencing the birth of a first child. Similar findings, highlighting the age-dependence of the effect of educational level have been reported in Norway (Kravdal, 1994) and Sweden (Tesching, 2012). A study on Finnish couples revealed that the educational levels of both spouses speeded up the transition to parenthood at ages 30-40, whereas a basic education of either spouse predicted a relatively high first-birth risk at younger ages (Jalovaara & Miettinen, 2013). Another study based on a relatively small sample of Finnish women living with a partner reported no effect of educational level, however (Berninger, 2013).

The postponement of parenthood is thought to place women in particular at a higher risk of remaining childless (Kneale & Joshi, 2008; Schmidt et al., 2012), and on the country-level later mean timing is associated with higher proportions of women remaining childless (Miettinen et al 2015). In addition to having a higher mean age at first birth, remaining childless is more common among highly educated women (Barthold, Myrskylä, & Jones, 2012; Hopcroft, 2015; Keizer et al., 2008; Kneale & Joshi, 2008; Kreyenfeld & Konietzka, 2008; Miettinen et al., 2015; Nettle & Pollet, 2008; Parr, 2005; Thomson et al., 2013; Toulemon & Lapierre-Adamcyk, 2000; Wood et al., 2014). A recent comparative study reported mainly negative educational gradients of childlessness in Europe and Australia, with the exception of eastern European countries (Wood et al., 2014). The differences were more pronounced in Southern Europe and the Netherlands than elsewhere. Highly educated women in particular showed strong variation in first-birth behaviour across the countries, indicating that this group is particularly sensitive to contextual factors in their childbearing behaviour.

Differences between educational groups in the proportion of women remaining childless have been narrowing or even reversing in the Nordic countries, however (Andersson et al., 2009; Hoem et al., 2006a; Kravdal & Rindfuss, 2008; Rønsen & Skrede, 2010). An increasing incidence of lifetime childlessness has been a trend in female cohorts born after the Second World War in the Nordic countries (Andersson et al., 2009; Frejka & Calot, 2001) and elsewhere (Miettinen et al., 2015; Rowland, 2007).[5] Childlessness among highly educated women has not increased as much in the Nordic countries however, and has even declined in some cases (Andersson et al., 2009; Kravdal & Rindfuss, 2008; Rønsen & Skrede, 2010). Increasing first-birth rates at higher ages in Sweden were found to contribute to a weaker link between the timing and the chance of first births across female cohorts born in the 1960s and later (Persson, 2010). Similarly, differences across educational groups in the proportion of childless women diminish strongly at higher ages in the Nordic countries (Andersson et al., 2009).

[5] Childlessness was also fairly common in female birth cohorts born at the beginning of the 20th century (Rowland, 2007). Moreover, the increase in childlessness may have stagnated by now in some countries (Miettinen et al., 2015).

The overall incidence of childlessness in Finland has been rising among female cohorts born since the late 1940s (Andersson et al., 2009; Frejka & Calot, 2001; Miettinen et al., 2015), reaching 17-18 per cent among women born in the early 1960s (Väestöntutkimuslaitos, 2015). This development is characterised by a rising trend among less highly educated women in particular, whereas the increase has been slower among the more highly educated (Pajunen, 2013), or has even reversed (Andersson et al., 2009). Childlessness among women born in the 1960s is relatively high among those with a basic and an upper-tertiary education, amounting to over 20 per cent (Pajunen, 2013). It is noteworthy, however, that these changes in cohort fertility patterns have coincided with a substantial shift in the educational distribution of the population (Ruokolainen & Notkola, 2007). A comparison of different studies (Andersson et al., 2009; Pajunen, 2013; Ruokolainen & Notkola, 2007) also indicates that the results are sensitive to how educational level is categorised.

Childlessness trends differ among men and women. Evidence from the Nordic countries, including Finland (Nikander, 1995), indicates that more-highly-educated men, at least in the younger birth cohorts, are less likely to remain childless (Fieder & Huber, 2007; Goodman & Koupil, 2009; Kravdal & Rindfuss, 2008; Lappegård et al., 2011; Rønsen & Skrede, 2010). Elsewhere the association between education and remaining childless varies from positive to flat to negative (Barthold et al., 2012; Hopcroft, 2015; Keizer et al., 2008; Kiernan, 1989; Kneale & Joshi, 2008; Miettinen et al., 2015; Nettle & Pollet, 2008; Parr, 2010; Thomson et al., 2013; Toulemon & Lapierre-Adamcyk, 2000; Weeden, Abrams, Green, & Sabini, 2006). It was found in a recent comparative study on European countries that childlessness at the age 40-44 was more common among men with a lower level of education in 13 out of 19 countries (Miettinen et al., 2015). Childlessness in the US (Hopcroft, 2015; Weeden et al., 2006) is more common among highly educated men, even if the association is weaker than among women, whereas in Canada (Ravanera & Beaujot, 2014) and Australia (Parr, 2010) men with a lower level of education are more likely to remain childless.

Evidence from the Nordic countries shows rising levels of remaining childless among men, too, but in contrast to the results among women there is no indication of a weakening in educational differences (Kravdal & Rindfuss, 2008; Lappegård et al., 2011; Rønsen & Skrede, 2010). In Finland, the proportion of childless men aged 49 amounted to 25 per cent among those born in the early 1960s, meaning that one in four men in this cohort remain childless (Väestöntutkimuslaitos, 2015). This figure is seven or eight per cent higher than among women in the respective birth cohort. The proportion of childless men with no more than a basic education, measured at the age of 40-44, was as high as one third.

2.2.2 EDUCATION AND HIGHER-ORDER PARITIES

The postponement of parenthood also tends to relate to fertility after the first child, attributable to the biological constraints on childbearing among women in particular (Leridon & Slama, 2008; Schmidt et al., 2012), and to other factors such as family-proneness (Gerster et al., 2007; Kreyenfeld, 2002). Andersson et al. (2009), for example, showed with regard to the Nordic countries that the age at having the first child was negatively related to the number of children among mothers.[6] Against the general trend of negative educational gradients in fertility, however, when women of the same age at having the first child were compared in the same study, the more highly educated had larger numbers of children (Andersson et al., 2009). Indeed, when the age at having the first child is controlled for in regression models, highly educated women have higher rates of second and third births (Berinde, 1999; Gerster et al., 2007; Hoem & Hoem, 1989; Kravdal, 1992; Kravdal, 2001; Kravdal, 2007; Kravdal & Rindfuss, 2008; Oláh, 2003; Tesching, 2012; Vikat, 2004)[7]. A positive association between both parents' level of education and second as well as third births was present among Swedish and Norwegian couples (Duvander & Andersson, 2006; Duvander, Lappegård, & Andersson, 2010).

According to recent comparative studies on European countries, the educational gradient in second births varies according to region, extending in most countries from neutral to positive (Bavel & Rózanska-Putek, 2010; Klesment, Puur, Rahnu, & Sakkeus, 2014; Wood et al., 2014). Third-birth gradients, in turn, vary widely across countries (Wood et al., 2014). Eastern Europe is an exception, with negative gradients in both second and third births. As for first births, variation across countries was widest among highly educated women (Wood et al., 2014). Some changes across cohorts have also been documented: in Norway, for example, the negative educational gradients in second or third births among women decreased in the cohorts born in 1940-1960 (Kravdal, 2001; Kravdal & Rindfuss, 2008). More-highly-educated mothers in Australia were less likely to have a second child, but the differences were attributable to age at the first birth (Parr, 2007). Similarly, among US women living in intact unions, highly-educated mothers were less likely to have a second child (Thomson et al., 2013).

[6] The link between a later mean age at parenthood and the number of children does not hold on the aggregate-level across cohorts or countries (Andersson et al., 2009; Schmidt et al., 2012).

[7] It has become more common in this strain of literature to take selection into the risk group into account, i.e. mothers of one (two) children for progressing to the second (third) child. Kravdal (2001) and Kreyenfeld (2002) report that the joint estimation of the first and second (and third) births yields less positive gradients for second (and third) births in women than separate estimations of each parity transition. Kravdal (2007), however, notes little difference between the two approaches when education is used as a time-varying covariate, producing positive estimates.

With regard to men, two Norwegian studies report that educational level stimulates higher-order births (Kravdal, 2007; Lappegård & Rønsen, 2013)[8], but the positive effect of education in general was found to have emerged only among male cohorts born later (Kravdal & Rindfuss, 2008). Another study on Sweden and Hungary reported no effect of education on second-birth rates (Oláh, 2003), whereas according to a study conducted in France and Sweden, men who are more highly educated are more likely to experience the birth of their first and second children within the same union (Thomson et al., 2013). It was found in a US study that education was not related to higher-parity births (Guzzo & Furstenberg, 2007), although relatively high rates of second and third births were found among men with a low level of education living in urban areas (Bronte-Tinkew et al., 2009). In Europe, a partner's high level of education, net of that of the mother, tends to increase second-birth rates (e.g. Bartus et al., 2013; Gerster et al., 2007; Klesment et al., 2014; Köppen, 2006; Kreyenfeld, 2002).[9] Moreover, some previous studies measuring the number of children indicate that no educational differences in women or men remain when the childless are excluded (Fieder & Huber, 2007; Nettle & Pollet, 2008; see however Barthold et al., 2012).

Previous Nordic studies have shown that, among women, the effect of educational enrolment is less decisive for entry into higher parities than for the first parity (Andersson, 2000; Kravdal, 2007; Tesching, 2012; Thalberg, 2013). This was also observed in Finland among young women (Vikat, 2004). In addition, unlike for first births, the effect of enrolment on higher-order births may not differ by age (Andersson, 2000). Among men, the negative effect of enrolment is weaker for higher-order parities similarly to women, and it is weaker overall as compared to women (Andersson & Scott, 2007; Kravdal, 2007; Oláh, 2003). In general, the inclusion of enrolment is likely to have a weaker effect on estimates of educational level in the case of higher-order compared to first births (e.g. Kravdal, 2007: 232).

With regard to Finland, Vikat (2004) found that educational level was positively associated with second and third births among women, the magnitude of the differences being comparable to those estimated for having a first child at ages 31-44. A comparative study also reported positive, and more so than in several European countries, effects of education on second-birth rates (Bavel & Rózanska-Putek, 2010). It was found in an earlier Finnish study that married women with higher levels of education had higher second-birth rates, whereas the opposite was the case among cohabiting women (Finnäs, 1995). It has also been documented with regard to Finnish mothers born in the 1950s that the more highly educated had slightly more children

[8] In the study by Lappegård & Rønsen (2013) education predicted further children with a different partner in a U-shaped manner.

[9] Not in some parts of Eastern Europe, however (Klesment et al., 2014). There is also some evidence of a positive effect on third births (Kravdal, 1992).

than the women in the other educational groups (Ruokolainen & Notkola, 2007).

2.2.3 EDUCATION AND THE NUMBER OF CHILDREN

A negative relationship between level of education and the number of children among women has been a standard finding in the literature (e.g. Skirbekk, 2008): in other words, a higher achieved educational level is typically related to lower lifetime fertility. However, there is evidence that this pattern has been changing in the Nordic countries (Andersson et al., 2009; Kravdal & Rindfuss, 2008; Rønsen & Skrede, 2010): differences in lifetime fertility by educational level have been narrowing in the cohorts born around the mid-20th century, and are relatively small in more recent birth cohorts (see also Fieder & Huber, 2007; Goodman & Koupil, 2009; Hoem et al., 2006b). Researchers attribute this phenomenon to recuperation, meaning that the postponement of fertility across birth cohorts (or on the individual level) is accompanied with rising (or relatively high on the individual level) fertility at older ages, which contributes to the relatively high lifetime fertility and modest educational differences therein in the Nordic countries (Andersson et al., 2009; Frejka & Calot, 2001). A negative gradient in the number of children was found among Finnish women born in the 1940s (Nikander, 1992), whereas in some younger cohorts those with a lower-secondary education seem to accumulate slightly more children than those educated to lower and higher levels (Andersson et al., 2009; Ruokolainen & Notkola, 2007).

A growing number of studies deal with educational differences in male fertility. Evidence from the Nordic countries, including Finland (Nikander, 1995), indicates that the more-highly-educated men, at least in younger birth cohorts, have higher average lifetime fertility (Fieder & Huber, 2007; Goodman & Koupil, 2009; Kravdal, 2007; Kravdal & Rindfuss, 2008). Outside the Nordic countries, the association between education and fertility varies from positive to neutral to negative (Barthold et al., 2012; Hopcroft, 2015; Nettle & Pollet, 2008; Skirbekk, 2008; Toulemon, Pailhé, & Rossier, 2008; Weeden et al., 2006). Norwegian studies have documented two additional related trends. First, a positive gradient in the number of children emerged among male cohorts born in the 1940-1960s, attributable to changes in the progression to second and third births (Kravdal & Rindfuss, 2008). Second, having children with more than one female partner is becoming more common among men with lower levels of education (Lappegård et al., 2011; Lappegård & Rønsen, 2013; Rønsen & Skrede, 2010).

2.2.4 POTENTIAL CONFOUNDERS

Characteristics observable early in life, such as parental socioeconomic position, may potentially confound the associations between education and fertility. Previous studies indicate that more favourable parental socioeconomic characteristics postpone fertility (Hynes, Joyner, Peters, & DeLeone, 2008; Kiernan & Diamond, 1983). It is suggested in some studies that the effect of parental characteristics on first births is mediated to some extent by education or other adulthood characteristics (Blossfeld & Huinink, 1991; Rijken & Liefbroer, 2009; Thornton, 1980; Winkler-Dworak & Toulemon, 2007), but many report significant effects net of such adjustments (Dahlberg, 2015; Lappegård & Rønsen, 2005; Lappegård & Rønsen, 2013; Rijken & Liefbroer, 2009; Tölke & Diewald, 2003; Winkler-Dworak & Toulemon, 2007). According to a Swedish study, a maternal blue-collar position increases the first-birth risk in young women net of their own education and employment, whereas no corresponding effect was found related to the father's position or among men except for a decreasing effect of a paternal farmer position (Dribe & Stanfors, 2009).

Parental socioeconomic characteristics appear to be associated both negatively (Murphy & Wang, 2001; Rijken & Liefbroer, 2009) and positively (Goodman & Koupil, 2009) with the number of children among men net of their own education. According to the results of a Norwegian study, a higher parental educational level among men predicted higher rates of higher-order births with the same partner, net of education and income (Lappegård & Rønsen, 2013). Paternal and maternal characteristics may also have different effects on male fertility: the effect of the mother's status may be more negative, for example (Parr, 2010; Rijken & Liefbroer, 2009). Among women, correspondingly, the evidence points to a negative association, even net of education (Murphy & Wang, 2001; Parr, 2005), or to no association (Goodman & Koupil, 2009). A recent Swedish study reports differences in the eventual likelihood of becoming a parent by parental education only among women, and this effect is attributed to mediating variables (Dahlberg, 2015). Parental position has been negatively associated with the number of children among women in Finland (Nikander, 1992).

Many previous studies on the relationship between education and the transition to parenthood include controls for background characteristics (e.g. parental education, the number of siblings, parental separation, or type of living area in childhood), but the effects of enrolment, at least, persist (e.g. Blossfeld & Huinink, 1991; Huinink, 1995; Kravdal, 1994; Lappegård & Rønsen, 2005; Liefbroer & Corijn, 1999; Winkler-Dworak & Toulemon, 2007). Other studies on higher-order parities, albeit fewer in number, also control for background, or at least run tests, without any major effect (e.g. Kravdal, 2007; Kravdal & Rindfuss, 2008; Lappegård & Rønsen, 2013).

Individual characteristics such as personality or intelligence may also be relevant in this context, even if they are less frequently included in studies assessing the relationship between education and fertility. A previous study on British women considered personality traits as potential confounders of the association between education and the timing of motherhood (Tavares, 2010). Many studies report an association between personality traits and fertility behaviour overall (e.g. Jokela, Alvergne, Pollet, & Lummaa, 2011; Miller, 1992). For instance, it was found in a US study that a few personality traits were associated with the number of children among women in particular, of which a negative effect of openness to experience was the only one attenuated by parental socioeconomic status and education (Jokela et al., 2011). Previous findings also indicate that intelligence predicts later and lower fertility among women in particular, with varying parts of this relationship attributed to the mediating role of education (Kanazawa, 2014; Reeve, Lyerly, & Peach, 2013; Retherford & Sewell, 1989).

Other approaches that do not include observed characteristics in the analyses have been tried to overcome the confounding problem. Few previous studies have modelled the transition to parenthood and the transition out of education, simultaneously allowing unobserved heterogeneity of the two outcomes to be correlated (Baizán & Martín-García, 2006; Billari & Philipov, 2004; Martín-García & Baizán, 2006; Martín-García, 2009). Evidence from several European countries indicates that, among women, the two outcomes have joint determinants and the association is thus partly attributable to such (unobserved) characteristics (Baizán & Martín-García, 2006; Billari & Philipov, 2004; Martín-García & Baizán, 2006). Among men, evidence from Spain, France and Germany suggests that such characteristics are less important or not relevant at all (Baizán & Martín-García, 2006; Martín-García, 2009).

A strain of studies in economics have used changes in compulsory-schooling laws to investigate any causal effects of education on fertility among women, in order to overcome problems related to endogeneity. The evidence on the effect of education on the number of children is inconclusive, and the results appear to be sensitive to context and measurement, even if there seems to be a causal effect of education on the timing of motherhood (Fort, Schneeweis, & Winter-Ebmer, 2014 and the references therein). For example, it was found in a study on Norwegian women that continuing in education led to the postponement of motherhood, but not to changes in the proportion of women remaining childless or in the number of children (Monstad et al., 2008). Skirbekk et al. (2006) also looked for a causal effect of education on fertility, using marginal age at the end of compulsory school, based on the month of birth, to predict the tempo and quantum of fertility among Swedish women. They found evidence of a causal effect on the timing of the first and second births, but not on the number of children.

A recent study based on a US sample of monozygotic female twins investigated the causal effect of education on completed fertility (Amin & Behrman, 2014). There was evidence of a causal effect on timing and the number of children, but not on remaining childless. Comparisons among ordinary siblings have also been used in studies on very young mothers, who tend to end up with low educational attainment: some researchers attribute this largely to selection and not to the influence of childbearing on education, but the evidence is generally inconsistent (Geronimus & Korenman, 1992; Hofferth, Reid, & Mott, 2001; Hoffman et al., 1993; Ribar, 1999).

2.2.5 STUDIES IN THE FIELD OF BEHAVIOURAL GENETICS

A strong focus in the field of behavioural genetics is on comparisons between monozygotic (MZ) twins (sharing all their genes and being virtually identical at the DNA-sequence level) and dizygotic (DZ) twins (sharing, on average, one-half of their segregating genes). In the light of their differences it is possible to distinguish between genetic, and common and unique environmental influences on traits and on associations between multiple traits (Boomsma, Busjahn, & Peltonen, 2002; Neale & Cardon, 1992). Common environmental influences refer to all such influences that make twins within a pair similar, whereas unique environmental influences refer to all those that produce dissimilarities. Rather than accounting for specific observed confounding covariates, researchers adopting the quantitative-genetics approach typically begin by investigating the extent to which variation in traits or co-variation between them—here, fertility and education—can be attributed to the three underlying sources of variance and covariance.

Previous twin studies have reported evidence of genetic and common environmental effects for both education and fertility, whereas the association between the two—especially with respect to male fertility—has received less attention. Previous estimates of the contribution of inter-individual genetic differences to variation in educational level based on US and European twin studies have ranged from one-fifth to almost one-half of the total variance (Kohler & Rodgers, 2003; Neiss, Rowe, & Rodgers, 2002; Rodgers et al., 2008; Silventoinen et al., 2004), and estimates of both common and unique environmental contributions also vary.

Several twin and family studies conducted in Denmark and the United States have investigated variation in fertility outcomes (Kohler, Rodgers, & Christensen, 1999; Kohler & Christensen, 2000; Kohler & Rodgers, 2003; Kohler, Behrman, & Schnittker, 2011; Mealey & Segal, 1993; Miller, Bard, Pasta, & Rodgers, 2010; Rodgers, Kohler, Kyvik, & Christensen, 2001; Rodgers, Bard, & Miller, 2007; Rodgers & Doughty, 2000). Evidence of moderate genetic influences has been found in the case of outcomes such as the chance of having a first child and the number of children, and also for variables more clearly related to fertility motivation such as age at the first attempt to have a child and the desired number of children. These studies imply that genetic influences are stronger in the case of fertility onset than on the total number of children, and some of them reported weaker common environmental than genetic effects (e.g. Rodgers et al., 2001).

Cohort-specific variation is also possible: genetic effects explaining variation in the number of children were found to be stronger in Danish twin cohorts experiencing fertility decline than in other birth cohorts, the estimates ranging between zero and 40-50 per cent in females and the corresponding estimates of environmental factors also varying (Kohler et al., 1999). A study on UK female twins reported both moderate genetic (26%) and common environmental (14%) effects on age at first birth, but also variation in estimates across different birth cohorts (Tropf et al., 2015). However, two previous studies on age at first birth report weak (Neiss et al., 2002)[10] or no (Rodgers et al., 2008) genetic component underlying this trait, in the latter case even in a Danish female cohort experiencing fertility decline. All these studies indicate that common environmental factors play a role in first-birth timing, and that unique environmental factors (not distinguishable from measurement error) are the most influential.

According to previous evidence from behavioural genetics studies, assessments of the genetic and common environmental contributions to the association between the level of education and fertility are inconsistent. It was found in a Danish twin study that the same genetic influences did not contribute to the number of children and the level of education (Kohler & Rodgers, 2003). The common environmental influences affecting fertility among women were largely found to influence educational level as well, whereas there was only a small overlap between genetic and common environmental factors among men. However, it is unlikely that educational differences in completed fertility were fully accounted for in this study given that more than half of the participants were younger than 40 at the end of the follow-up.

A study on US female twins reported a negative association between education and completed fertility among women that was largely attributable to overlap in the genetic variance in education and fertility, but concluded that education was the necessary mechanism linking genetic variance to fertility outcome (Kohler et al., 2011). Another study on US women and men reported no overlap of genetic variance and only modest overlap of common environmental variance between expected educational achievement in youth and the number of children in adulthood (Miller et al., 2010). The estimates of variance in the components of expected education in this study did not correspond to previous estimates of achieved attainment in the United States, however (Neiss et al., 2002; Rodgers et al., 2008; Silventoinen et al., 2004).

Complementing the twin studies assessing the relationship between education and the number of children are two behavioural-genetics studies addressing the association between education and the timing of having the first child. Neiss et al. (2002), who analysed US female and male siblings in a pooled sample, attributed the association between education and age at the first birth to common genetic and environmental sources. Rodgers et al. (2008), in turn, in their study on Danish twins attributed the association solely to common environmental sources. It is implied in both of these studies that education mediates the effect of intelligence on age at first birth in a phenotypic model, but when latent factors are included the direct mediating effect is no longer significant.

[10] Female and male twins were analysed together as no significant interaction with gender was found in the univariate models.

3 THE FRAMEWORK AND THE AIMS OF THE STUDY

3.1 A SUMMARY OF THE PREVIOUS LITERATURE

The literature on the relationship between education and lifetime fertility is extensive, diverse, and largely based on studies on women. From a life-course perspective, fertility decisions could be described as consecutive life-course decisions creating variation in tempo and quantum (Huinink & Kohli, 2014; Kreyenfeld & Konietzka, 2008; Thomson et al., 2013). Individual life courses are age-regulated and susceptible to social institutions and historical change (Elder, 1992; Elder, 1994; Giele & Elder, 1998). The theoretical roots of most previous individual-level studies lie in micro-economics and other fields such as sociology and psychology, and concepts such as opportunity costs and the income effect (Becker, 1993a; Joshi, 1998) guide the hypotheses and give explanation to the empirical findings. The micro-economic framework and especially the assumption of gender specialisation have also been criticised, however (Esping-Andersen, 2009).

The strengths of the existing body of literature include its focus on the varying effects of education on fertility and on parity-specific analysis. Several event-history-based studies make a distinction between the effects of educational enrolment on the one hand and educational attainment on the other (e.g. Blossfeld & Huinink, 1991; Kravdal, 1994; Lappegård & Rønsen, 2005). The effect of enrolment is strong, especially with respect to first children (e.g. Andersson, 2000), and robust to different contexts, whereas the evidence on the relationship between the level of education net of enrolment and fertility is less consistent (e.g. Blossfeld, 1995; González & Jurado-Guerrero, 2006). Parity-specific analyses have contributed substantially to enhancing understanding of how education shapes individuals' family-life courses: education tends to relate more positively to higher-order births than to the process of having the first child (e.g. Kravdal, 2001; Tesching, 2012; Vikat, 2004).

The main challenge facing researchers in the field of education and fertility is that educational level as a measure captures differences between individuals not only in terms of the length of enrolment and human capital, but also related to problem-solving skills, family background and income level, for instance (Gustafsson & Kalwij, 2006b; Skirbekk et al., 2006). It is often difficult to untangle these different characteristics and thus to draw strong conclusions regarding the nature of the relationship between education and fertility. With a view to overcoming the potential problem of omitted variables, most studies control for background variables such as parental social position (e.g. Liefbroer & Corijn, 1999; Parr, 2005; Winkler-Dworak & Toulemon, 2007), which are unlikely to be adequate given the diverse nature of education.

Previous causal studies report less robust conclusions regarding the effect of education on having the first child or on the number of children, compared to the effect on the timing of childbearing (e.g. Amin & Behrman, 2014; Monstad et al., 2008; Skirbekk et al., 2006). One reason for this could be the weaker association of quantum than tempo with education, but it may also indicate the varying influence of other factors. Another challenge is the causal order of the variables, especially if this cannot be traced empirically in the dataset (Hoem & Kreyenfeld, 2006; Kravdal, 2004). Even if this were possible, endogeneity could hamper the drawing of strong conclusions. It is commonly assumed that education is more likely to influence fertility than vice versa, but there is also empirical evidence indicating otherwise (e.g. Cohen et al., 2011).

Much of the existing literature concerns women, although there is growing research interest in male fertility. Nordic studies in particular have documented several important points with respect to education and fertility in men, showing that (1) educational enrolment postpones fertility among men less strongly than among women (Andersson & Scott, 2007; Dribe & Stanfors, 2009; Thalberg, 2013); (2) highly educated men are less likely to remain childless (Lappegård et al., 2011; Rønsen & Skrede, 2010); (3) unlike the negative gradient in women's lifetime fertility, among men the positive gradient in the number of children shows no signs of weakening (Kravdal & Rindfuss, 2008); (4) education may positively predict higher-parity fertility in men (Duvander & Andersson, 2006; Duvander et al., 2010) and is less sensitive to issues of measurement than among women (Kravdal, 2007); and (5) fertility with multiple partners is most common among men with a low level of education (Lappegård & Rønsen, 2013).

However, there are still relatively few studies on age- and parity-specific differences in male fertility. There is also a shortage of research in the area of male fertility with respect to education that focuses on aspects such as male-female comparisons, the role of female characteristics in male fertility differences (and to some extent vice versa), time trends, parity-specific differences and causal patterns. It is unclear what role the problem of omitted variables plays in associations between education and fertility in men, for instance, although it is suggested in some studies on the transition to parenthood that it may be less serious than among women (Baizán & Martín-García, 2006; Martín-García, 2009). In addition, studies in the field of behavioural genetics are increasingly contributing to the body of literature on the underlying genetic and other influences on fertility in women (Kohler et al., 2006; Mills & Tropf, 2015). Less is known about such influences among men or on the complex relationship between education and fertility in general.

3.2 THE FINNISH CONTEXT

Contextual influences such as childcare provision, the flexibility of the educational system, the organisation of the labour market and gender relations are likely to affect the relationship between education and fertility, by reducing the direct or opportunity costs of childbearing, for example (Ilmakunnas, 1994; Rønsen, 2004; Rønsen & Skrede, 2010). Less pronounced negative differences in fertility between women of different educational levels are to be expected in contexts in which women wishing to combine educational and professional careers with motherhood face less severe obstacles (Blossfeld, 1995; Lappegård & Rønsen, 2005). The relationship between female participation in the labour force and total fertility on the aggregate level changed from negative to positive between 1970 and 1996 (Brewster & Rindfuss, 2000). Although on the individual level women in various countries find it difficult to combine parenthood and employment, the extent of this incompatibility varies according to the context (Bernhardt, 1993; Brewster & Rindfuss, 2000). The role of contextual influences on the relationship between education and fertility in men has received much less attention, and it is not obvious what is to be expected. Given that having a child is usually a long-term project for a couple, the prevailing gender relations, including the role of the father at work and at home, presumably influence the fertility behaviour of both men and women (Bernhardt, 1993; Goldscheider et al., 2015).

This study is based on Finnish male and female cohorts born in the 1940s and 1950s. The context implies low living standards in the mid-20th century, but rising levels thereafter (Jäntti, Saari, & Vartiainen, 2006). Finland was a poor country, still at or recovering from war in the 1940s when the men and women under investigation were born. Economic growth and structural change in the second half of the century led to an increase in overall living standards. A specific characteristic of Finland is that labour-force participation among women with pre-school children was high even in the 1950s and 1960s, and the proportion of women working part-time was very low even compared to other Nordic countries (Rønsen & Sundstrom, 2002). In 1978 the proportion of Finnish mothers of children aged 0-6 participating in the labour force reached 73 per cent, compared to 69 per cent in Sweden and 48 per cent in Norway. Between the years 1976 and 1999, only around 13 per cent of employed women were working part-time in Finland, compared to more than 35 per cent in Sweden and Norway. Men were still more highly educated than women in the cohorts born in the 1940s, but this was reversed later on (Havén, 1999).

Public support for families strengthened in Finland during the second half of the 20th century as part of the welfare-state expansion (Rønsen, 2004), and women and men born in the 1940s and the 1950s were able to benefit from this to an increasing extent during their prime childbearing years. Overall, childcare arrangements for small children were strongly addressed in Finnish family policy until the 1990s, when the focus shifted towards direct income transfers (Ruokolainen & Notkola, 2007). The universal right to paid family leave dates back to 1964. The length of the leave was extended several times in subsequent decades (from 9 weeks in 1964 to 44 weeks in 1987), and the income-replacement level also rose (from 45% to 70-80% in 1982) until it was cut in 1994 (to a maximum of 66%). The proportion of pre-school children in publicly funded day care rose from less than one in ten in 1975 to nearly half in 1990 (Leira, 2006). The more equal division of labour between mothers and fathers was facilitated by legislation from the 1970s onwards, and Finnish fathers have been eligible to share some parental leave with mothers since 1978 (Haataja, 2004; Leira, 2006). The initial two-week leave to which fathers were entitled was extended later on (Haataja, 2004). Their caregiver role continued to be weak in comparison with that of mothers, however: 39 per cent of fathers used their right to parental leave in 1990, but they accounted for only few per cent of all parental-leave days in Finland (Ellingsaeter & Leira, 2006; Haataja, 2004).

The Nordic social-democratic welfare state with universal social rights guaranteed to its citizens developed in Finland comparatively late: it is only since the late 1980s that the country could be described as following the Nordic model in the level and extent of welfare provision (Kettunen, 2001; Julkunen, 1999). Generous support for families and the aim of reducing gender inequality are pivotal in Nordic social policies (Rønsen & Skrede, 2010), although some family-related benefits were cut in Finland during the 1990s recession. Even if the comparatively similar positions of men and women and the family model of two breadwinners are characteristic of Finnish society, gender differences still persist with regard to unpaid and paid work. Men in families with small children continue to spend shorter periods at home and contribute less to unpaid work than women (Lammi-Taskula, 2007). Men also still earn more in various life phases (Sauli, 2013) despite the fact that women have a higher level of education on average (Repo, 2012).

Unions and childbearing are closely related in Finland (Nikander, 1992; Nikander, 1995). The proportion of children born outside marital unions began to increase in the early 1970s, rising from 10 per cent in 1975 to nearly 40 per cent in 2000, but the proportion of children born to non-married or non-cohabiting woman remained small (5% in the 1970s and 1980s) (Ruokolainen & Notkola, 2007). Moreover, modern efficient contraceptives such as the pill and the coil were increasingly used in Finland in the 1960s and 1970s (Ruokolainen & Notkola, 2007). According to a population-based survey conducted in 2000, many members of the female cohorts born in the late 1930s and early 1940s were already users of modern contraceptive methods, although the practice was increasingly common among the younger cohorts (Kosunen, Sihvo, Nikula, & Hemminki, 2004). Behavioural patterns differed according to educational group, however, in that the use of the pill was more common among the highly educated.

3.3 THE AIMS OF THE STUDY

The aims of this study as listed below could be described as descriptive and analytical. On the descriptive level they were: (1) Among men in particular, to study age-specific fertility by educational level and parity, and to decompose educational differences in the lifetime number of children by parity; (2) To investigate the associations of educational level and early-life socioeconomic characteristics with lifetime fertility among men and women. The analytical-level aims were: (3) To study the extent to which early-life socioeconomic characteristics or other characteristics shared by siblings explain the association between educational level and lifetime fertility; (4) To assess the extent to which the association among men is mediated by other socioeconomic characteristics in adulthood; (5) To assess the extent to which the association between educational level and the chance of having a first child is attributable to common environmental or genetic characteristics shared by twin siblings, and to determine whether the latent sources of the co-variation are similar to those between educational level and age at the birth of the first child (AFB). The research questions in short were:

1. How does age-specific fertility vary by parity and educational group in men? What parities drive the educational differences in the number of children men have in their lives (I)?

2. In what ways are educational level and early-life characteristics associated with lifetime fertility, in other words the number of children, the chance of having a first child and fertility beyond the first child? (II, III)

3. Are the associations between educational level and lifetime fertility attributable to early-life characteristics or to other characteristics shared by siblings? (II, III)

4. To what extent do other socioeconomic characteristics (occupational class and income) mediate the association between educational level and lifetime fertility among men in adulthood?[11] (III)

5. To what extent is the association between educational level and the chance of having a first child attributable to underlying genetic or environmental factors? Are these factors similar for the education-AFB association? (IV)

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[11] This was not studied among women because analysis based on the available measures would be hampered by the difficulty in establishing the causal order between other socioeconomic characteristics, more closely reflecting labour-market participation, and fertility (Bernhardt, 1993; Brewster & Rindfuss, 2000).

The study is based on unique Finnish data sets on families (I-III) and twins (IV). Both baseline data sets are linked to register-based information on lifetime fertility. Advantage is taken of the availability in the family data set of socioeconomic and demographic measures in childhood and adulthood, and also of the possibility to identify siblings. Dizygotic and monozygotic twin pairs are analysed in the twin data. The study covers Finnish men and women born in the 1940s and 1950s, and emphasises the eventual outcomes in individuals' lives – the lifetime number of children women and men in these birth cohorts accumulated. One reason for adopting this approach was that the birth cohorts in question are relatively old now, and their childbearing behaviour may differ in several respects from that of today's young adults: hence, too, the emphasis on the eventual outcomes of fertility instead of early fertility or tempo, for example. All in all, given the sources of data available and their uniqueness in some respects, it was deemed the most relevant to provide information on the patterns of cohort fertility and therein specifically on the number of children.

The total lifetime number of children was analysed as the main outcome variable. Given that life-course processes leading to having the first child as opposed to subsequent children may differ (Kravdal, 2001; Kravdal, 2007; Kreyenfeld, 2002; Rønsen, 2004; Vikat, 2004), separate analyses were conducted on the chance of having a first child and the number of children beyond the first child. In line with much earlier research, educational differences in fertility constitute the starting point. It is therefore assumed that education is the variable that is more likely to exert influence on fertility than vice versa (e.g. Rindfuss et al., 1980), despite the potential of reverse causality as outlined in the literature review.

4 MATERIALS AND METHODS

4.1 DATA SETS

Sub-studies I-III are based on the same original data set: a 10-per-cent sample of households drawn from the 1950 Finnish Census of the Population (Statistics Finland, 1997). These data were subsequently linked to sociodemographic information from quinquennial censuses in 1970–1995, and the Finnish Population Register for birth records up to 2009. The original sample consisted of 411,628 persons. The sample used in all the sub-studies based on this data set (I-III) was restricted to the 1940–50 birth cohorts.

The sample used in sub-study I comprised men who belonged to the household population in 1950 (n=48,460), of whom 91 per cent could be linked to other sources of information via personal identification codes. Of these, 41,226 were present in the census at the age of 30–34 (1970/75/80), and information on the level of education was thus available. Those not present in the census at the age of 45-49 were excluded from the dataset (N=2,386). Two observations were further dropped due to the unrealistic value of age at having the first child. The final sample consisted of 38,838 men. Loss to follow-up is likely to be attributable mainly to emigration, in particular to Sweden in the late 1960s and early 1970s, and to a lesser extent to mortality between 1950 and 1990–95. The data on women were derived from the original dataset in accordance with the same criteria as for the men (N=36,806).

Sub-studies II and III are based on the same data set as sub-study I. However, the study population is restricted to persons born between 1940 and 1950 and, in addition to belonging to the household population as in sub-study I, lived in a one-parent or two-parent family at the time of the census in 1950 (44,672 women and 46,782 men). Observations with missing information on early-life variables (580 women and 648 men) or a missing personal identification code (5,106 women and 4,009 men), and those lost to follow-up regardless of any available identification code at the age of 30–34 (2,727 women and 2,760 men) or 45–49 (1,047 women and 2,281 men) were further excluded. Two observations of males with an unrealistic value of age at the first birth were excluded. The final study sample consisted of 35,212 women (sub-study II) and 37,082 men (sub-study III). Sisters and brothers were identified on the basis of an identification code collected in 1950 for the place of residence, household and family. The women in the sample came from 26,207 families, in 6,979 of which at least two female siblings could be identified. The men, in turn, came from 27,305 families, in 7,671 of which at least two male siblings were identified. This identification procedure did not distinguish between biological and non-biological siblings.

The loss to follow-up is likely to be attributable mainly to emigration, in particular to Sweden in the late 1960s and early 1970s, and to a lesser extent to mortality between 1950 and 1990–95. Those lost to follow-up before 1970 were more likely to be women, born before 1945, from lower socioeconomic backgrounds, from mother-only families and from Lapland (Elo, Martikainen, & Myrskylä, 2014). These differences were not large, however, and therefore were unlikely to bias the findings. A sensitivity analysis was conducted on men as part of sub-study I to assess potential bias from those lost in the follow-up between 1970 and 1985/90/95 and therefore excluded from the analytical sample. In terms of age-specific fertility, the exclusion of this sub-population did not have much effect despite its selective nature. Men in this sub-group had a lower level of education and fewer children, on average, than the men in the analytical sample, but this may have been attributable to migration or early death (see also Andersson & Sobolev, 2013).

The data used in sub-study IV were derived from the older cohort of the Finnish Twin Cohort Study (Kaprio & Koskenvuo, 2002). The baseline questionnaire was mailed in 1975 to all same-sex Finnish twin pairs who were born before 1958 and were both alive in 1974. A follow-up questionnaire was sent in 1981 to all twin pairs to whom the baseline questionnaire had been sent, regardless of their participation in the 1975 survey. The response rates in these surveys were 89 and 84 per cent, respectively. Those born in 1950–1957 and not living with their co-twin in 1981 (n=7,842) were included in the study sample. This decision was based primarily on the empirical observation that compared with the general population of Finland (Statistics Finland, 2007: 87–88), a relatively large proportion of these twins were childless. This finding accords with earlier indications that married men and women are slightly underrepresented in the twin data compared with the whole Finnish population (Kaprio et al., 1979: 32–36). The few respondents belonging to a triplet or quadruplet, as well as those who had not given information about their education in either the 1975 or the 1981 survey (n=22), were also excluded from the analysis. The final study population consisted of 7,820 twin individuals: 3,592 men and 4,228 women.

Zygosity was assessed in the 1975 and 1981 surveys on questions concerning the similarity of appearance at an early school age. This method left a small proportion (7%) of pairs unclassified because of missing or conflicting responses, although some were correctly classified later by means of genetic testing. The validity of this questionnaire method for classifying zygosity has been assessed in a Finnish study by using 11 highly polymorphic blood markers in a sample of 104 twin pairs classified as MZ or DZ. The observed agreement between the results of the blood tests and the questionnaire-based method was 100 per cent, and the probability of misclassification of a twin pair was estimated to be less than two per cent (Sarna, Kaprio, Sistonen, & Koskenvuo, 1978). The analytical sample included 1,592 male and 1,986 female complete twin pairs, of which 418 were MZ and 1,035 DZ male pairs, and 583 were MZ and 1,249 DZ female pairs. Zygosity was unknown for 139 male and 154 female twin pairs.

4.2 VARIABLES

Sub-studies I-III are based on the same data set and the same measures of fertility and education. Monthly information on biological children born alive was linked to data on birth records from 1970 to 2009. Children born before 1970 were included except for those who did not live with their fathers at the time of the population census in 1970, when personal identification codes were in use. The study participants were 59–69 years old at the end of the follow-up. The lifetime number of children in the analytical sample was similar among men (1.81) and women (1.86), thus any bias attributable to unknown paternity is likely to be small (see also Chapter 6.2, Methodological considerations). The main outcome variable in sub-studies II and III was the lifetime number of children. Other indicators of lifetime fertility were the chance of having a first child (having any children) and the number of children born beyond the first one.

The main explanatory variable used in sub-studies I-III, the level of education, was measured at the age of 30–34, divided into four classes in line with the official categorisation of Statistics Finland from 1988 (Statistics Finland, 1989): basic, lower-secondary, upper-secondary and tertiary. The basic level refers to a maximum of nine years of general education (9 years or less). The lower-secondary level refers to brief vocational training (<3 years) undertaken in addition to basic education. Upper-secondary education means either academic education (matriculation) or vocational training (≥3 years) undertaken in addition to basic education. Finally, the tertiary level refers to either a university degree or vocational training at the highest level (such as for specialised nurses and engineers) (≥4 years after general education).

Longitudinal register-based information on the formation and dissolution of marital unions constituted the basis on which marital history was measured in sub-studies I and III. In sub-study I the variable was categorised as never-married (18%), intact-married (first marriage not dissolved due to divorce or the partner's death: 52%), divorced/widowed (20%) and remarried (11%). Marital history was dichotomised in sub-study III in terms of whether the person had been married or not. It was not possible in the data to identify marriages that were formed and dissolved before 1970. Longitudinal information on cohabitation was not available either, although it was still relatively uncommon in Finland in the birth cohort under study, becoming more common from the early 1970s (Finnäs, 1993). According to a survey of women born in 1943-1947, around five per cent were cohabiting when their first child was born, and a similar proportion was neither cohabiting nor married (Nikander, 1995). Having the first child in a cohabiting union was more common among men with a lower level of education.

A number of variables were used to measure early-life conditions in sub-studies II and III. The socioeconomic characteristics included parental education, occupational status of the family head, and measures of overall living conditions. The parental educational level refers to the highest educational qualification achieved by either parent (74% of the parents had the same level), categorised as less than primary school, primary school and more than primary school. The occupational status of the family head was categorised as professional or administrative, manual worker, farmer with < 10 hectares (100 a) of land, farmer with ≥ 10 hectares of land, and self-employed or other. The three variables measuring overall living conditions in childhood included house ownership (owner, renter, other or unknown), crowding (number of persons per heated room: < 2, 2 < 3, 3 < 4, ≥ 4), and standard of living (poor, modest or good). The 'poor' category in this proximate measure referred to households with no modern facilities such as electric light, 'modest' to households with one item, and 'good' to those with at least two items. The classification reflects the generally modest level of housing in Finland in the 1950s.

The other observed early-life characteristics in sub-studies I-III covered year of birth, family structure and place of residence in childhood. Family structure was measured in terms of family type (two parents with children, mother and children, father and children) and number of siblings (0, 1–2, 3 or more) in the household in 1950. The place of residence covered five geographical areas: the Helsinki (capital) region, the rest of Uusimaa (the area surrounding the capital region in the southern part of Finland), western Finland, and eastern and northern Finland, both of which were mainly agricultural areas in 1950. All these and the early-life characteristics were measured in the 1950 census, when the men under investigation were between the ages of zero and 10.

Socioeconomic characteristics of men in adulthood, other than education, were also measured in sub-study III. Occupational position was classified as manual worker, lower white collar, upper white collar, farmer or self-employed, and other or unknown. Of those in the farmer or self-employed category, 64 per cent were farmers. With regard to income, the values from different years of (taxable) income reported in the census were first converted into (taxable) income in the year 2012 (Statistics Finland, 2013) and then divided into quintiles (< 18,752, 18,753 – 28, 346, 28,346 – 41,020, 41,025 – 54,414, ≥ 54,415). Three per cent of the men in the sample had no income.

Sub-study IV is based on a different data set than the other three, and some of the variables also differed between the studies. For sub-study IV, register-based comprehensive data on live births was available up until June 2009, at which time the surviving participants were 51–59 years of age. These data were linked to the baseline survey data using the unique personal identification number given to all Finnish citizens. Given that the information on fertility is register-based, underestimation of the numbers of children born to men is a possibility. However, this is unlikely to seriously affect the results because the proportion of children without a known father in Finland during the last decades of the twentieth century was small (1.3% of children aged 0–17 years in 1997) (Kartiovaara & Säkkinen, 2007). The main fertility variable in the analysis is the chance of having a first child (having any children).

The measure of educational level was based on the 1981 survey (when the respondents were aged 23–31), and if not available then on the 1975 survey (when they were aged 17–25). The respondents were asked: “What kind of schools and courses have you attended?” and nine response alternatives were given. Those who were still studying when reporting their level of education were assumed to have reached the next educational category given in the questionnaire. The highest level of education was then classified into four groups: primary school (6 years or less), more than primary school (7 years), junior high school (10 years), and senior high school (12 years) or more. Having more than a primary-school education here means having completed primary school plus at least one year of vocational education.

4.3 STATISTICAL METHODS

4.3.1 INDIVIDUAL-LEVEL ANALYSES (I-IV)

The methods used in sub-study I were descriptive, including the calculation of age-specific fertility rates (ASFR) and interquartile ranges (IQR), and decomposing differences between groups in the number of children by parity. ASFRs were calculated for each one-year age group and educational group separately. Given that fertility was calculated for a cohort surviving to the age of 45–49, a constant number of person years at risk - in other words the number of men in the sample who were alive and resident in Finland at the age of 45–49 - was used for all ages in the denominator. The descriptive results were robust to the inclusion of men who were present in the data at the age of 30–34 but not at 45–49 (N=2,386). Arithmetic means and interquartile ranges (IQR) were used to describe location and variation in fertility. Standard deviations were also calculated, the results being very similar to the IQRs.

The educational gradient in the number of children was decomposed into differences in progression to parities one, two, three, and four or higher. Those with a basic education comprised the reference group. The decomposition was based on deriving the cohort’s lifetime number of children from the parity-progression ratios:

$$Number\ of\ children = P_0 + P_0P_1 + P_0P_1P_2 + \cdots = \sum_{i=0}^{\infty}\prod_{j=0}^{i} P_j$$

where P_i expresses the probability of progressing from parity i to parity i+1 conditional on having progressed to parity i. The contribution of each P_i to the total difference in the number of children between the two educational groups was approximated by

$$\Delta Number\ of\ children = \sum_i \left(\frac{\partial CFR}{\partial P_i}\right)\Delta P_i$$

where each partial derivative $\frac{\partial CFR}{\partial P_i}$ was calculated as an average between the reference group and the other educational group, and is the difference in parity progression ratio i between the educational groups (Pullum, Tedrow, &

Herting, 1989). The clustering by families in the data set was taken into account in the calculations of the standard errors.

The methods used in sub-studies II-IV included ordinary binary logistic and Poisson regression models (Lindsey, 1997):

$$log\left(\frac{p_i}{1-p_i}\right) = \mu + \boldsymbol{\beta x}_i$$

$$log(\lambda_i) = \mu + \boldsymbol{\beta x}_i$$

where p_i is the probability of having any children for the respondent i (i=1,2, ..., n), λ_i is the number (count) of children for the respondent i, μ is a constant, $\boldsymbol{x}_i$ is a vector of predictor variables and $\boldsymbol{\beta}$ is a vector of the corresponding coefficients. The logistic regression model assumes p_i to be binomially distributed and uses a logit link function. Poisson regression assumes λ_i to follow a Poisson distribution and uses a log link function. The Poisson regression was used to study two outcomes: the lifetime number of children among all women/men and the number of children beyond the first one among mothers/fathers only. Binary logistic regression was used to study the outcome of having any children. The sample used to estimate the models in sub-studies II and III necessarily varied according to the outcome of the analyses: the full sample of women/men (N=35,212 / N=37,082) was used for the main fertility outcome and for having any children, but in analysing the number of children beyond the first one only mothers/fathers (n=29,622 / n=29,943) were included. In addition, multinomial logistic regression was used in sub-study IV to study the probability of having either one or two, or three or more children, vs. no children. The method is similar to binary logistic regression but with more than two response categories.

The clustering of siblings or twins within families was taken into account throughout the analyses in the calculation of the 95-per-cent confidence intervals (CI). The bootstrap procedure with cluster resampling, with 1,000 replications and sibling sets as the clusters, was used in sub-studies II and III (Carpenter & Bithell, 2000). The results of the Poisson regression models are reported as incidence rate ratios (IRR=Exp^{β}), and those of the binary logistic regression models as odds ratios (OR=Exp^{β}). The relative risk ratio (RRR= Exp^{β}) with a similar interpretation to OR was used in sub-study IV in reporting the results of the multinomial logistic regression analysis. Separate models for women and men were run throughout unless otherwise indicated. The Stata statistical package, Version 11 (StataCorp, 2009) was used for the statistical analyses in sub-studies I-III, and Version 10 (StataCorp, 2007) in sub-study IV.

4.3.2 SIBLING FIXED-EFFECTS ANALYSES (II-III)

In addition to the conventional models described above, sibling fixed-effects (FE) versions of these models (Allison, 2009) were calculated in sub-studies II and III to find out whether unobserved characteristics shared by sisters/brothers contributed to the association between education and fertility. The sibling FE model controls for characteristics shared by (here: same-sex) siblings, which refer primarily to the family's social environment, but also to some genetically inherited characteristics. Similar methodology has been used previously in analyses of young-age parenthood and educational outcomes (Geronimus & Korenman, 1992; Hofferth et al., 2001; Hoffman et al., 1993; Ribar, 1999). The model adjusts for selective characteristics that are common to siblings. By default, the variation in the predictor variable, here education, is assumed to be exogenous to fertility, in other words it is only associated with fertility through education (e.g. Kohler et al., 2011). The possibility of characteristics unshared by siblings and affecting both fertility and education cannot be ruled out, however, in which case they would still confound the estimates (Holmlund, 2005; Lahey & D'Onofrio, 2010).

The logistic and Poisson sibling FE models can be described as follows:

$$log\left(\frac{p_{jt}}{1-p_{jt}}\right) = \mu + \boldsymbol{\beta x}_{jt} + \boldsymbol{\gamma z}_j + \alpha_j$$

$$log(\lambda_{jt}) = \mu + \boldsymbol{\beta x}_{jt} + \boldsymbol{\gamma z}_j + \alpha_j$$

where j (j=1,2, ..., n) refers to a family and t (t=1,2, ..., T) to a sibling in a family j, p_{jt} to the probability of having any children for a sibling t in a family j, and λ_{jt} to the number of children for a sibling t in a family j. μ is a constant, $\boldsymbol{x}_{jt}$ *a* vector of predictor variables varying within families, $\boldsymbol{z}_j$ a vector of predictor variables varying between families, and α_j stands for family-specific unobserved heterogeneity.

The sibling FE models were constructed by means of conditional maximum likelihood estimation, meaning that the likelihood function is conditioned on the sum of the counts over a sibling group (total number of children born to same-sex siblings of the same family). The constant and the unobserved heterogeneity term cancel out the equation in this procedure, and are not estimated, thereby allowing for any correlations between $\boldsymbol{x}_{jt}$ and α_j. Given that the estimation is based on within-family variation, coefficients for $\boldsymbol{z}_j$ are not estimated. In this FE approach the family indicator is used to capture unobserved family characteristics, and the model parameters for education are estimated from the variation between sisters/brothers. Thus, the models fully account for the characteristics shared by siblings, but at the cost of reducing the sample size because those with no sisters/brothers are excluded. Further, the sister/brother sets in which all sisters/brothers had a zero outcome (childless or no children beyond the first one) are excluded in the Poisson FE models (on the number of children or the number of children beyond the first), and those in which all sisters/brothers had the same outcome are excluded in the logistic FE regression model (on having any children). The analysed sister/brother sets include only those who were born between 1940 and 1950, and who were alive and living in the same household in 1950 at the time of the census.

4.3.3 BEHAVIOURAL GENETICS ANALYSES (IV)

The first step in the behavioural genetics analysis in sub-study IV was to calculate tetrachoric correlations (ρ) among the dichotomous variables for descriptive purposes. Tetrachoric correlation refers to correlations calculated for dichotomous variables from an underlying assumed standard normal distribution in order to estimate either covariance between co-twins across two traits (cross-twin/cross-trait covariance) or twin-pair resemblance in a trait (cross-twin/within-trait covariance).

Further, univariate and bivariate genetic twin models based on linear structural equation modelling (Neale & Cardon, 1992) were constructed for education and the chance in having any children, based on comparisons between MZ (being virtually identical at the DNA sequence level) and DZ (sharing, on average, one-half of their segregating genes) twins. These differences imply that a genetic twin design can distinguish between genetic, common environmental, and unique environmental sources of a trait and of associations between multiple traits (Boomsma et al., 2002; Neale & Cardon, 1992). Similarity between twins arises because of genetic or environmental influences shared by co-twins.

Genetic influences here refer to additive influences with a correlation of 1 within MZ pairs and 0.5 within DZ pairs. Common environmental influences refer to all such influences that make twins within a pair similar. Environmental influences that produce dissimilarities in the twin pair are referred to as unique environmental influences. Measurement error is modelled as part of this source of variance. Dominant as opposed to additive genetic influences, referring to interactions between alleles in the same loci may also be present. However, this source of variance cannot be estimated simultaneously with common environmental effects if only twins reared together are included in the data, as is the case in this study.

Linear structural equation modelling, Cholesky decomposition in this case, based on pair covariance in MZ and DZ twins can be used to estimate the extent to which variation in a trait or covariation between two traits is attributable to each of the three sources assumed to be uncorrelated with each other. Covariance between co-twins in a trait (cross-twin/within-trait covariance) reflects either genetic or common environmental influences on the trait. As a rule, the greater the covariance in MZ compared with DZ twin pairs, the greater is the estimate of genetic influences on the trait. Similarly, covariance in co-twins between two traits (crosstwin/cross-trait covariance) refers to shared genetic or shared environmental influences on the covariation, and the MZ/DZ twin pair ratio is informative of whether similarity increases because of genetic or common environmental causes. Figure 1 depicts a univariate model.

As depicted in Figure 2, bivariate Cholesky decomposition was used to study the latent sources of covariation between education and the chance in having any children. The results are reported as correlations between genetic, common environmental and unique environmental sources of variance in education and having any children. For example, correlation between the genetic components of education and having any children would suggest that the same or closely linked genes influence both of these traits. Correlation between the genetic components is referred to as r_a, and between the shared and unique environmental correlations as r_c and r_e, respectively. The genetic correlation (r_a) is calculated by $r_a = a_{xx}a_{yx}/\sqrt{a_{xx}^2(a_{yx}^2 + a_{yy}^2)}$, where index a refers to genetic factors, x to education and y to fertility outcome (Kohler et al., 2011). The common (r_c) and unique (r_e) environmental correlation is calculated in the same way except that c/e replaces a.

An association between education and fertility independent of any factors shared by twins is modelled as a unique environmental correlation, which arises from a higher correlation between education and fertility in a twin individual (cross-trait correlation) than between education and fertility in a co-twin (cross-twin/cross-trait correlation). In contrast, a cross-twin/cross-trait correlation that is not lower than cross-trait correlation for a twin individual indicates that the correlation between these two traits is attributable to overlap in genetic (when cross-twin/cross-trait correlation is higher within MZ than DZ pairs) or common environmental (when there is no difference in the cross-twin/cross-trait correlations within MZ and DZ pairs) factors.

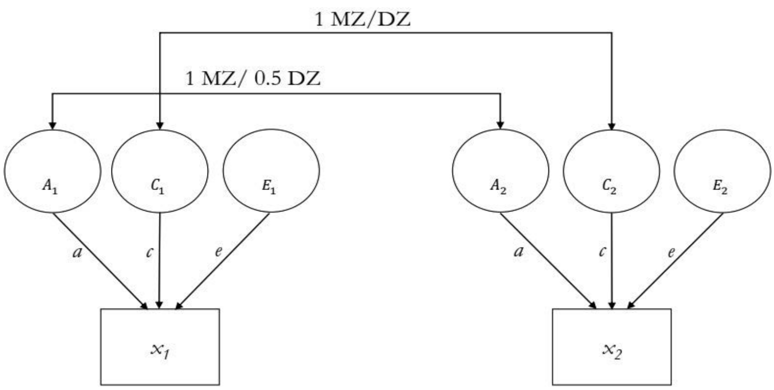

Figure 1 A univariate model for education (x_i) for MZ and DZ twins (i=1,2): A_i, C_i and E_i refer to latent genetic, common environmental, and unique environmental components and *a, c* and *e* to the respective coefficients

This kind of genetic model (Figure 2) does not include as a parameter direct causality between the two measured variables – which is often the main interest in social-science applications (Kohler et al., 2011)[12]. In other words, if

[12] For a discussion on genetic causes in social sciences see also Freese (2008).

genetic factors are found to cause the covariation between education and fertility, for example, they may influence both variables directly, and/or influence fertility indirectly through their effect on education. The former option (only) would imply a spurious association whereas the latter allows causality between the two variables. The same logic applies to unique and shared environmental factors behind the co-variation.

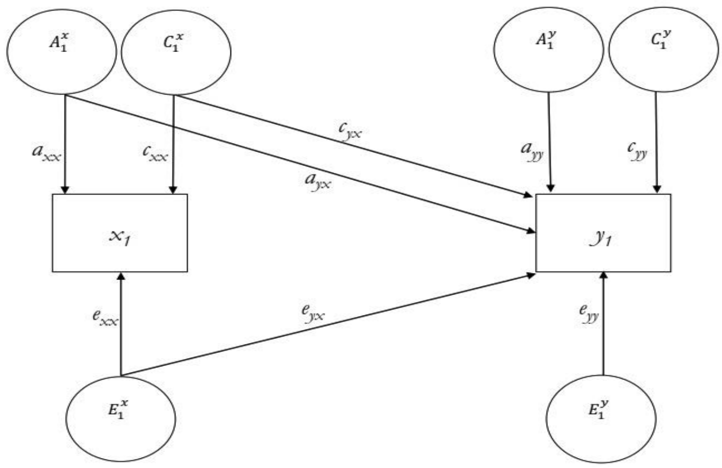

Figure 2 A bivariate model for education (x_i) and fertility (y_i) shown for one twin i=1 only: A_1, C_1 and E_1 refer to latent genetic, common environmental, and unique environmental components, and *a, c* and *e* to the respective coefficients

The statistical significance of the different types of variance components in the bivariate analyses were tested by means of nested models, and further examined via the change in model fit (chi-square values) according to the degrees of freedom between them. In addition, Akaike information-criterion (AIC) indexes were calculated to distinguish between the fit of different models. Finally, the genetic modelling was repeated for the association between education and AFB. The analysis was conducted separately for women and men. The Mx statistical package was used in the genetic modelling (Neale, 2003).

The underlying assumptions behind genetic modelling are strong. They include the absence of assortative mating (Neale & Cardon, 1992: 18–22) and gene-environmental interactions (Neale & Cardon, 1992: 22–23), and may be violated: numerous studies have produced evidence of assortative mating, for example (e.g. Schwartz & Mare, 2005). Nevertheless, its presence should, by default, make the results on the magnitude of the genetic contribution conservative: phenotypic assortment by education will push the genetic relatedness of DZ twins closer to that of MZ twins, and thus generate apparent common environmental variance if random mating is assumed.

5 RESULTS

5.1 DESCRIPTIVE RESULTS

5.1.1 AGE-SPECIFIC FERTILITY BY EDUCATION AND PARITY IN MEN (I)

The level of education in the Finnish cohort born in 1940–1950 was still relatively low, and higher among men than women. Almost half of the women (46%) and men (45%) were not educated beyond the basic level. Over a quarter (27% of women and 28% of men) reached the lower-secondary level, and even fewer reached higher levels (upper-secondary: 14% of men, 15% of women; tertiary: 14% of men, 12% of women). The average lifetime numbers of children born to women (1.86) and men (1.81) in this cohort were relatively high by current standards. Fewer men (80.6%[13]) than women (84.2) were parents, whereas on average the fathers appeared to have slightly higher fertility (2.24) than the mothers (2.21). The mean age at which men had their first child was 26.6 years, as opposed to 30.1 and 34.0 years for the second and third children, respectively (Table 1). The corresponding ages in women were lower (24.5, 27.6 and 30.7 years, respectively), with a larger gender difference at higher parities. The mean age at having a child of any parity was 2.6 years higher among men (29.6) than women (27.0).

Figures 3 and 4 show the ASFRs among men by education and in contrast to that of women. Men made the transition to parenthood an average 2.1 years later than women did, and had higher fertility levels at older ages. Men reached 90 per cent (95%, 99%) of their cumulative fertility rate at age 38.3 (41.6, 48.4), whereas women reached this percentile at the age of 35.1 (37.6, 41.6). In general, fertility was slightly less concentrated around the mean childbearing age among men than among women (the IQR of having a child of any parity was 8.4 years for men and 7.9 years for women). The fertility rate peaked later in the more highly educated groups of men: at the age of 24 among those with a basic education compared with 28 among those with a tertiary education (Figure 4). Men in their late teens and early twenties with a lower level of education had higher fertility levels than their more-highly-educated counterparts. The difference narrowed in the mid-twenties, and by the late twenties the positions had reversed: from the age of 26 onwards those with a tertiary education had higher fertility rates than those with a basic education (except for a few older age groups registering very few births).

[13] The data sets used in sub-studies II and III differed slightly (see Chapter 4.1), causing marginal differences in results in some cases: for example, the proportion of fathers was 80.6 per cent in the data set used in sub-study I compared with 80.8 per cent in the data set used in sub-study III.

Table 1. *Fertility timing by parity and level of education, Finnish men born in 1940–50*

	N	Mean	SE	IQR	Lower quart.	Upper quart.
Age at having a child of any parity						
Basic	29,817	29.0	0.05	8.7	24.2	32.9
Lower secondary	19,401	29.3	0.06	8.5	24.5	33.0
Upper secondary	10,001	30.3	0.08	7.9	25.8	33.7
Tertiary	11,071	31.1	0.07	7.2	27.0	34.2
Total	70,290	29.6	0.03	8.4	24.9	33.3
Age at having the 1st child						
Basic	13,250	26.1	0.05	5.8	22.6	28.4
Lower secondary	8,845	26.3	0.05	5.8	22.8	28.6
Upper secondary	4,511	27.2	0.07	5.8	23.8	29.6
Tertiary	4,716	28.1	0.07	5.2	25.1	30.3
Total	31,322	26.6	0.03	5.9	23.1	29.0
Age at having the 2nd child						
Basic	9,987	29.4	0.06	7.1	25.5	32.6
Lower secondary	6,721	30.0	0.07	6.8	26.1	32.9
Upper secondary	3,573	30.9	0.09	6.2	27.4	33.6
Tertiary	3,919	31.4	0.08	5.5	28.2	33.7
Total	24,200	30.1	0.04	6.7	26.4	33.1
Age at having the 3rd child						
Basic	4,177	33.2	0.10	8.5	28.6	37.1
Lower secondary	2,585	33.9	0.11	7.5	29.9	37.4
Upper secondary	1,305	35.0	0.16	7.4	31.1	38.5
Tertiary	1,665	35.3	0.14	6.6	31.5	38.1
Total	9,732	34.0	0.06	7.7	29.8	37.5

The pattern was qualitatively similar among women (Figure 3), although the differences between educational groups in their late teens and early twenties were much larger than among the men. Although men had higher fertility rates than women in their late thirties and early forties (23 vs. 14 per 1,000, respectively, at the age of 40), the absolute differences between men with a tertiary and a basic education were of the same magnitude as those among women at these ages (8 vs. 9 per 1,000, respectively, at the age of 40). Fertility timing among the men with a higher level of education was characterised by both a later start and less dispersion compared with their less-highly-educated counterparts (Table 1). The IQR of the age at having a child of any parity was 8.7 years among those with a basic education and 7.2 years among those with a tertiary education. This pattern of lower variance among the more highly educated was also present for the first, second, and third parities. With regard to the timing of the first child, men with a tertiary education had the smallest IQR (5.2), but there were no differences between the other educational groups (5.8 for each).

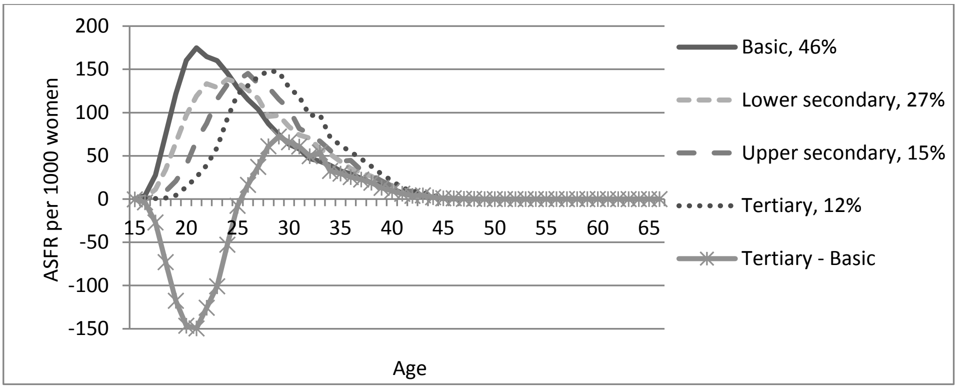

Figure 3 ASFR by level of education, Finnish women born in 1940–1950

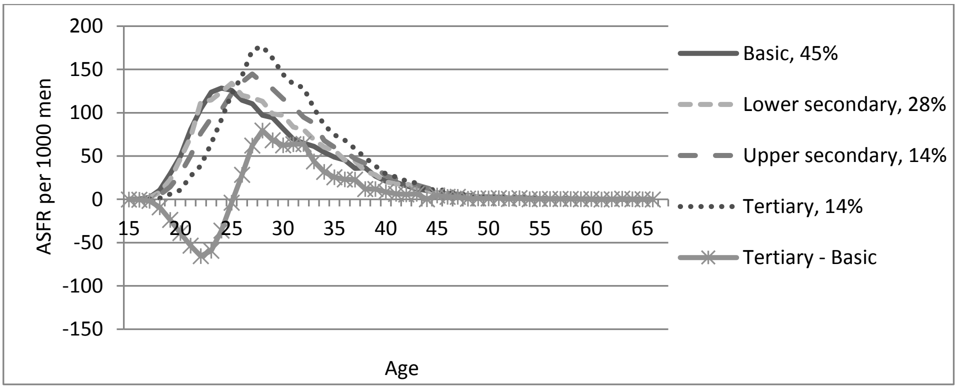

Figure 4 ASFR by level of education, Finnish men born in 1940–1950

A positive gradient of cumulative ASFR emerged among men in their early thirties, being higher from the age of 30 in the group with a tertiary education than among those with a basic education (Figure 5). The difference widened thereafter until their early forties, after which the gap increased only moderately. Of the total difference in the lifetime number of children between men with a tertiary and a basic education (0.35 as Table 2 shows) 90 per cent was evident by the age of 41, and 95 per cent by the age of 45. The 95-per-cent level was reached in all educational groups by the age of 41–42. On the cumulative level, by the age of 29 those with a tertiary education had overtaken those with lower levels of education in terms of fatherhood (Figure 6). A positive educational gradient emerged in the early thirties, and 95 per cent of the final proportional difference between those with a tertiary and a basic education was evident by the age of 39.

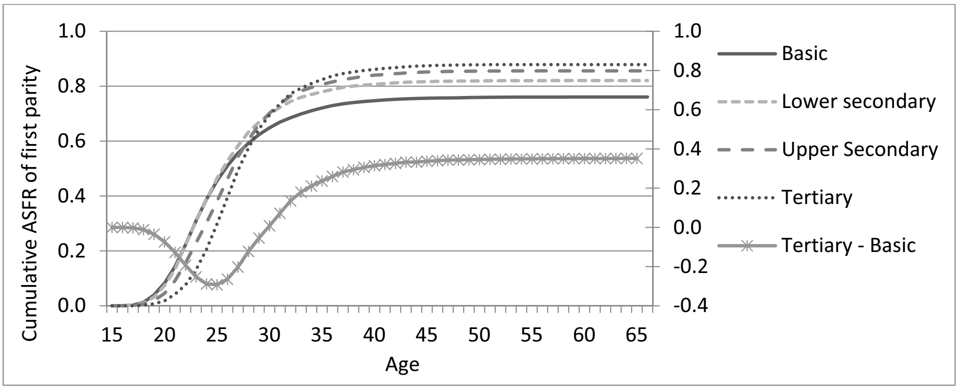

Figure 5 Cumulative ASFR of first parity (the proportion of fathers) by level of education, Finnish men born in 1940–1950

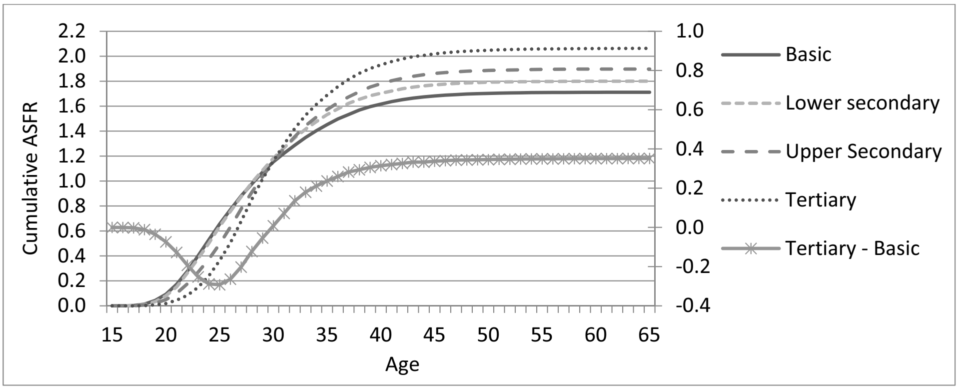

Figure 6 Cumulative ASFR of births of any parity by level of education, Finnish men born in 1940–1950

Figure 7 shows the ASFRs separately for groups of men with a varying marital history. The more highly educated were more likely to be either intact-married (tertiary 63%, basic 46%) or remarried (tertiary 14%, basic 10%), and less likely to have never married (tertiary 8%, basic 23%) or to have been divorced or widowed (tertiary 14%, basic 21%). The lifetime number of children was highest among the remarried (2.37). The intact- married (2.09) had higher fertility levels than the divorced or widowed (1.92), and the never-married had the lowest levels (0.53). Educational differences in the number of children by marital history were generally small: among the intact-married men, for example, those with a basic education had 2.09 children as opposed to 2.19 children among those with a tertiary education.

With the exception of the never-married, the more highly educated men also had later fertility timing within the marital groups. The pattern of less dispersion in timing among the more highly educated in general held among the intact-married and the never-married, whereas no such pattern was observed in the divorced and widowed groups. Age at having a child of any parity was the least dispersed in the intact-married group and the most widely spread in the remarried group (IQR: 7.9 vs. 11.3 years).

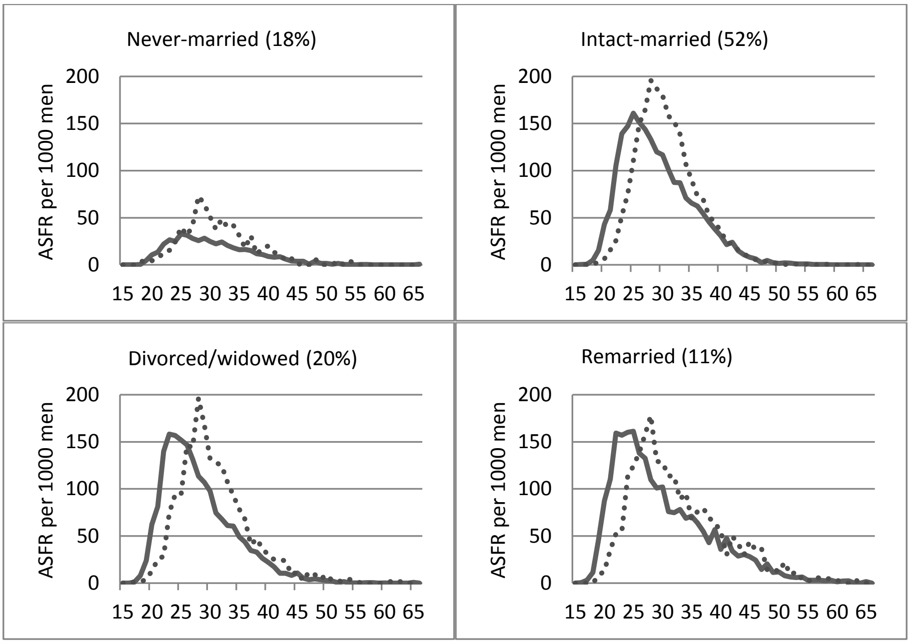

Figure 7 ASFR by marital history and level of education, Finnish men born in 1940–50, with age on the x-axis. Only the rates for men with a basic (continuous line) and tertiary (dotted line) education are shown.

Table 2. *Decomposition of the lifetime number of children by parity, Finnish men born in 1940-1950*

	Parity contribution (Δ %)					Δ N of children	N of children	N
Level of education	0[1]	1	2	3+[2]	Total			
Basic[3]	-	-	-	-	-	-	1.71	17,422
Lower secondary	151	9	-35	-25	100	0.09	1.80	10,778
Upper secondary	114	27	-27	-14	100	0.19	1.90	5,271
Tertiary	77	30	2	-9	100	0.35	2.06	5,367

[1] Refers to the contribution of progression ratio out of parity 0 to parity 1.
[2] Refers to the sum of the contributions of progression ratios out of parity 3 to parity 4 and. correspondingly to higher order parities.
[3] Reference category

Table 2 shows the differences between educational groups in the number of children decomposed into differences in progress to parities one, two and three or higher. Men with a basic education comprised the reference group. The lifetime number of children was higher in each more-highly-educated group – among men with a tertiary education (2.06) it was 20 per cent higher than among those with a basic education (1.71). Progression to the first parity accounted for most of the positive gradient (>77%), and progression to the second also contributed positively to the differences (9–30%), whereas progression from the second to the third and higher parities diminished them somewhat.

5.1.2 LIFETIME FERTILITY BY EDUCATION AND EARLY CHARACTERISTICS (II, III)

Table 3. *Lifetime fertility by level of education, Finnish women and men born in 1940-50*

Level of education	N	%	N of children M	Having any children %	N of children beyond the first[1] M
Women					
Basic	16,216	46	1.94	86.1	1.26
Lower secondary	9,429	27	1.83	84.8	1.16
Upper secondary	5,231	15	1.73	81.6	1.12
Tertiary	4,336	12	1.73	78.5	1.20
Total	35,212	100	1.85	84.1	1.20
Men					
Basic	16,561	45	1.71	76.2	1.25
Lower secondary	10,275	28	1.80	82.0	1.20
Upper secondary	5,073	14	1.90	85.7	1.22
Tertiary	5,173	14	2.06	87.9	1.35
Total	37,082	100	1.81	80.8	1.24

[1]Among mothers / fathers only.

Table 3 shows the differences in lifetime fertility by level of education among women and men in the study cohort. As described earlier, only slightly more children in total were registered to women than men on average, whereas male fertility was concentrated in a smaller proportion. The difference in the proportions of parents was largest among men with the lowest and the highest levels of education: among those with a basic level of education, for example, 75.2 per cent of the men and 86.1 per cent of the women had one or more children. A negative gradient among women and a positive gradient among men were observed in the lifetime number of children and the proportion of parents (those with one or more children), the differences being somewhat larger among men.

Education differentiated the groups less in fertility beyond the first child among parents, but some differences persisted. A weak U-shaped association with educational level emerged among both women and men: those with a secondary education had the fewest children. In terms of children beyond the first one, the mothers with the lowest level of education and the fathers with the highest had the most (1.26 and 1.35, respectively). The associations between education and lifetime fertility were very similar when the year of birth in the 11-year study cohort was controlled for (see Table 6, Figure 8 and Figure 9).

Table 4. *Lifetime fertility by early characteristics (a separate model for each characteristic), controlled for year of birth, Finnish women born in 1940-50*

	N	%	N of children[1]		Having any children[2]		N of children beyond the first[3]	
			IRR	95% CI	OR	95% CI	IRR	95% CI
Parental level of education								
Less than primary	5,113	15	1.00		1.00		1.00	
Primary	26,433	75	0.94	(0.92-0.97)	0.96	(0.87-1.04)	0.91	(0.88-0.94)
More than primary	3,666	10	0.88	(0.85-0.91)	0.68	(0.61-0.76)	0.90	(0.86-0.94)
Occupational status of the family head								
Professional/administrative	5,488	16	1.00		1.00		1.00	
Workers	14,937	42	1.07	(1.04-1.10)	1.36	(1.25-1.47)	1.03	(0.99-1.06)
Farmers, <10 ha	8,910	25	1.12	(1.09-1.15)	1.34	(1.22-1.48)	1.12	(1.08-1.16)
Farmers, ≥10 ha	2,728	8	1.10	(1.06-1.14)	1.21	(1.07-1.38)	1.12	(1.07-1.18)
Self-employed, other[4]	3,149	9	1.07	(1.03-1.11)	1.25	(1.11-1.41)	1.05	(0.99-1.09)
Family type								
Two parents & children	32,693	93	1.00		1.00		1.00	
Mother & children	2,272	6	0.98	(0.95-1.01)	1.00	(0.89-1.12)	0.97	(0.93-1.02)
Father & children	247	0.7	0.98	(0.88-1.08)	0.76	(0.56-1.09)	1.05	(0.91-1.21)
Number of siblings								
0	5,200	15	1.00		1.00		1.00	
1-2	16,946	48	1.03	(1.01-1.05)	1.09	(1.01-1.20)	1.03	(0.99-1.06)
3-	13,066	37	1.11	(1.08-1.14)	1.12	(1.08-1.30)	1.15	(1.12-1.19)
House ownership								
Owner	21,041	60	1.00		1.00		1.00	
Renter	12,106	34	0.93	(0.91-0.94)	0.89	(0.84-0.95)	0.90	(0.88-0.92)
Other, unknown	2,065	6	0.97	(0.94-1.01)	0.97	(0.85-1.10)	0.96	(0.91-1.01)
Crowding (persons/heated room)								
<2	11,379	32	1.00		1.00		1.00	
2<3	11,569	33	1.03	(1.01-1.04)	1.10	(1.03-1.19)	1.02	(0.99-1.05)
3<4	5,758	16	1.06	(1.04-1.09)	1.12	(1.02-1.23)	1.08	(1.05-1.12)
≥4	6,506	18	1.10	(1.07-1.12)	1.22	(1.12-1.34)	1.11	(1.08-1.16)
Standard of living								
Poor	10,099	29	1.00		1.00		1.00	
Modest	16,243	46	0.95	(0.93-0.97)	0.93	(0.87-1.00)	0.92	(0.90-0.95)
Good	8,870	25	0.89	(0.87-0.91)	0.77	(0.71-0.83)	0.87	(0.85-0.90)
Living area								
Helsinki region	2,616	7	1.00		1.00		1.00	
Rest of Uusimaa	2,049	6	1.06	(1.02-1.10)	1.26	(1.07-1.47)	1.03	(0.97-1.09)
Western Finland	13,942	40	1.10	(1.07-1.13)	1.33	(1.19-1.48)	1.09	(1.04-1.14)
Eastern Finland	15,094	43	1.14	(1.10-1.17)	1.32	(1.19-1.47)	1.17	(1.11-1.22)
Northern Finland	1,511	4	1.21	(1.15-1.26)	1.59	(1.34-1.91)	1.24	(1.16-1.32)

[1] Method of analysis: Poisson regression.
[2] Method of analysis: binary logistic regression.
[3] Method of analysis: Poisson regression. Analysis on mothers only.
[4] Includes those with unknown status.

The associations between characteristics early in life and lifetime fertility depended on gender (Table 4 and Table 5). Many indicators of socioeconomic advantage in childhood predicted a lower number of children among women. For example, a higher level of parental education predicted lower fertility: women whose parents had more than a primary-school education had 12-percent fewer children than those whose parents were not educated up to the basic level (IRR 0.88 95% CI 0.85, 0.91). Women from manual-worker and farmer families had more children than those from families in which the occupational status of the head was professional or administrative. Family type was not associated with female fertility, but women with more siblings had more children. Those living in rented housing in 1950 had fewer children than those living in owner-occupied dwellings, whereas those living in more crowded dwellings had more children, as did those with a lower standard of living in childhood. Living in the capital region (Helsinki) predicted lower fertility than living in less affluent and more heavily agricultural areas.

Table 5. *Lifetime fertility by early characteristics (a separate model for each characteristic), controlled for year of birth, Finnish men born in 1940-50*

	N	%	N of children[1]		Having any children[2]		N of children beyond the first[3]	
			IRR[4]	95% CI	OR[4]	95% CI	IRR[4]	95% CI
Parental level of education								
Less than primary	5,019	14	1.00		1.00		1.00	
Primary	28,032	76	**1.03**	(1.01-1.06)	**1.37**	(1.26-1.47)	0.94	(0.90-0.98)
More than primary	4,031	11	**1.09**	(1.05-1.13)	**1.66**	(1.48-1.84)	**0.97**	(0.93-1.02)
Occupational status of the family head								
Professional/administrative	5,935	16	1.00		1.00		1.00	
Workers	15,774	43	**0.96**	(0.94-0.98)	**0.87**	(0.80-0.94)	**0.97**	(0.95-1.01)
Farmers, <10 ha	9,147	25	**0.99**	(0.96-1.02)	**0.74**	(0.67-0.81)	1.08	(1.05-1.13)
Farmers, ≥10 ha	2,879	8	1.06	(1.02-1.09)	**0.89**	(0.79-1.01)	1.14	(1.10-1.19)
Self-employed, other[5]	3,347	9	**1.02**	(0.98-1.05)	**0.94**	(0.84-1.06)	1.05	(1.01-1.10)
Family type								
Two parents & children	34,486	93	1.00		1.00		1.00	
Mother & children	2,309	6	**0.94**	(0.91-0.97)	**0.80**	(0.72-0.89)	0.97	(0.93-1.00)
Father & children	287	0.8	0.88	(0.80-0.97)	0.65	(0.50-0.86)	0.93	(0.82-1.06)
Number of siblings								
0	5,683	15	1.00		1.00		1.00	
1-2	17,820	48	1.05	(1.03-1.08)	1.07	(0.98-1.16)	1.07	(1.04-1.11)
3-	13,579	37	**1.07**	(1.05-1.10)	**0.92**	(0.85-1.00)	1.17	(1.13-1.20)
House ownership								
Owner	21,971	59	1.00		1.00		1.00	
Renter	12,864	35	**0.98**	(0.97-1.00)	**1.15**	(1.09-1.21)	**0.93**	(0.90-0.95)
Other, unknown	2,247	6	0.99	(0.95-1.03)	0.96	(0.86-1.07)	0.99	(0.94-1.05)
Crowding (persons/heated room)								
<2	12,187	33	1.00		1.00		1.00	
2<3	12,063	33	**0.98**	(0.96-1.00)	**0.92**	(0.87-0.98)	1.00	(0.97-1.03)
3<4	6,112	16	**0.97**	(0.95-1.00)	**0.82**	(0.75-0.89)	**1.02**	(0.99-1.06)
≥4	6,720	18	**0.96**	(0.94-0.99)	**0.72**	(0.67-0.79)	**1.05**	(1.01-1.09)
Standard of living								
Poor	10,458	28	1.00		1.00		1.00	
Modest	17,216	46	**1.02**	(1.00-1.04)	**1.27**	(1.19-1.35)	0.94	(0.92-0.97)
Good	9,408	25	**1.04**	(1.01-1.06)	**1.49**	(1.38-1.61)	**0.93**	(0.90-0.96)
Living area								
Helsinki region	2,947	8	1.00		1.00		1.00	
Rest of Uusimaa	2,122	6	**1.00**	(0.96-1.03)	**0.96**	(0.82-1.12)	1.01	(0.95-1.06)
Western Finland	14,688	40	**1.04**	(1.01-1.07)	**1.01**	(0.90-1.11)	1.07	(1.03-1.11)
Eastern Finland	15,677	42	**1.03**	(1.00-1.06)	**0.84**	(0.75-0.93)	1.12	(1.08-1.16)
Northern Finland	1,648	4	**1.06**	(1.00-1.11)	**0.87**	(0.73-1.01)	1.16	(1.09-1.25)

[1] Method of analysis: Poisson regression.
[2] Method of analysis: binary logistic regression.
[3] Method of analysis: Poisson regression. Analysis on fathers only.
[4] Difference to women significant at 5% risk level in a pooled sample of women and men indicated in bold.
[5] Includes those with unknown status.

Among the men, on the other hand, several indicators of socioeconomic advantage in early life predicted higher fertility (Table 5). For example, those whose parents with at least a primary-school-level education had nine per cent more children than those whose parents were not educated up to the primary level (IRR 1.09 95% CI 1.05, 1.13). Men from manual-worker families had slightly fewer and those from large farms slightly more children than those from families in which the occupational status of the head was professional or administrative. Men living in less-crowded or better-equipped housing in childhood had slightly more children. The men differed from the women in that coming from a one-parent family predicted lower fertility. As among the women, men with a larger number of siblings and from less affluent and more heavily agricultural areas had more children, although these associations were weaker in magnitude.

In the case of the two other fertility outcomes, having any children and fertility beyond the first child, the associations with early characteristics among the women were qualitatively similar to those with the number of children, whereas among the men, the nature of the associations depended more on the fertility outcome in question. For example, men from farmer families or who had lived in a very crowded or poorly equipped household in childhood tended to remain childless, but conditional on having any offspring had a relatively large number of children. In general, given the number of significant associations between early characteristics and lifetime fertility, men were more dissimilar to women in having a first child than in fertility beyond that.

5.2 ANALYTICAL RESULTS: EDUCATIONAL DIFFERENCES

5.2.1 THE EFFECT OF OBSERVED EARLY CHARACTERISTICS (II, III)

Model 0 in Table 6 shows the estimated associations between education and lifetime fertility among both women and men based on the regression models. A comparison with Model 1 reveals that simultaneous adjustment for all observed early variables[14] moderately diminished the educational gradient in the lifetime number of children among the women. The change in the point estimates (IRRs) of the number of children was 3-28 per cent, calculated as (0.92-0.89)/(1.00-0.92)*100.

[14] Early characteristics in Table 6 and subsequently refer to those listed in Table 5: parental level of education, occupational status of the family head, family type, number of siblings, house ownership, crowding, standard of living and living area.

Table 6. *Lifetime fertility by education without (Model 0) and with (Model 1) controls for early characteristics, Finnish women and men born in 1940-50*

	Women				Men			
Number of children[1]								
Model	0		1		0		1	
Level of education	IRR	95% CI	IRR	95% CI	IRR	95%CI	IRR	95%CI
Basic	1.00		1.00		1.00		1.00	
Lower secondary	0.95	(0.93-0.96)	0.95	(0.93-0.96)	1.05	(1.03-1.07)	1.06	(1.03-1.08)
Upper secondary	0.89	(0.87-0.91)	0.92	(0.90-0.94)	1.11	(1.09-1.14)	1.13	(1.10-1.15)
Tertiary	0.89	(0.87-0.91)	0.92	(0.90-0.95)	1.20	(1.18-1.23)	1.22	(1.19-1.25)
Having any children[2]								
Model	0		1		0		1	
Level of education	OR	95% CI	OR	95% CI	OR	95%CI	OR	95%CI
Basic	1.00		1.00		1.00		1.00	
Lower secondary	0.89	(0.83-0.96)	0.89	(0.83-0.96)	1.45	(1.36-1.54)	1.42	(1.33-1.52)
Upper secondary	0.71	(0.65-0.77)	0.74	(0.67-0.80)	1.90	(1.73-2.07)	1.84	(1.69-2.03)
Tertiary	0.59	(0.54-0.64)	0.63	(0.58-0.69)	2.28	(2.09-2.51)	2.22	(2.01-2.46)
Number of children beyond the first[3]								
Model	0		1		0		1	
Level of education	IRR	95% CI	IRR	95% CI	IRR	95%CI	IRR	95%CI
Basic	1.00		1.00		1.00		1.00	
Lower secondary	0.93	(0.91-0.95)	0.93	(0.91-0.96)	0.96	(0.93-0.98)	0.97	(0.94-0.99)
Upper secondary	0.90	(0.87-0.93)	0.93	(0.90-0.97)	0.97	(0.94-1.00)	1.00	(0.97-1.04)
Tertiary	0.96	(0.93-1.00)	1.00	(0.96-1.04)	1.08	(1.05-1.11)	1.12	(1.08-1.16)

Model 0: education and year of birth.
Model 1: education, year of birth and early characteristics.
[1] Method of analysis: Poisson regression.
[2] Method of analysis: binary logistic regression.
[3] Method of analysis: Poisson regression. Analysis on mothers / fathers only.

Establishing the correct order of early characteristics is not straightforward. If parental education and the occupational status of the family head were assumed to have preceded other characteristics, then controls for these variables could be justified before controlling for other variables. As indicated in the additional analyses, if these two characteristics were controlled for first, the change in the point estimates would be 0-18 per cent (lower secondary IRR 0.95 (95% CI 0.93, 0.96), upper secondary IRR 0.91 (95% CI 0.89, 0.93), tertiary IRR 0.91 95% CI 0.89, 0.94), and further adjustments for other variables would have less effect.

With regard to parity among the women, a similar change was observed for the number of children as for additional children, but not for having the first child. The gradient in the number of children beyond the first one among mothers decreased by 6-96 per cent when all early variables were controlled for simultaneously, and by 1-45 per cent if only parental education and the occupational status of the family head were controlled for. The respective changes in the point estimates (ORs) of having any children were negligible (<11% and <7% respectively). Controlling for observed early characteristics did not decrease the educational gradient in lifetime fertility among the men, irrespective of the fertility outcome.

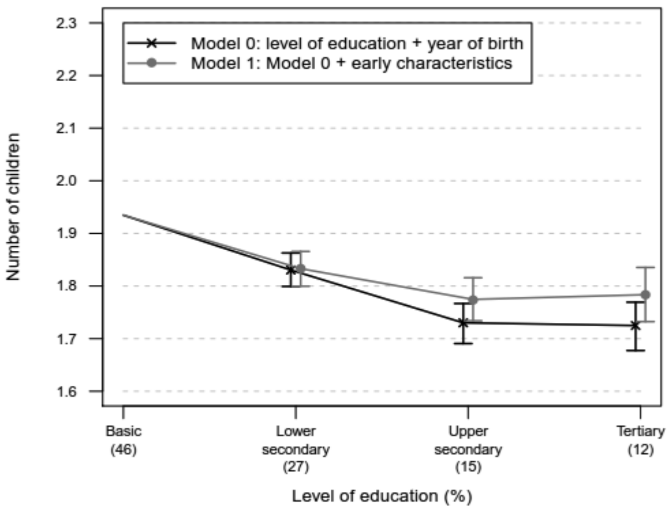

Figure 8 The number of children by level of education based on Poisson regression analysis, Finnish women born in 1940-50

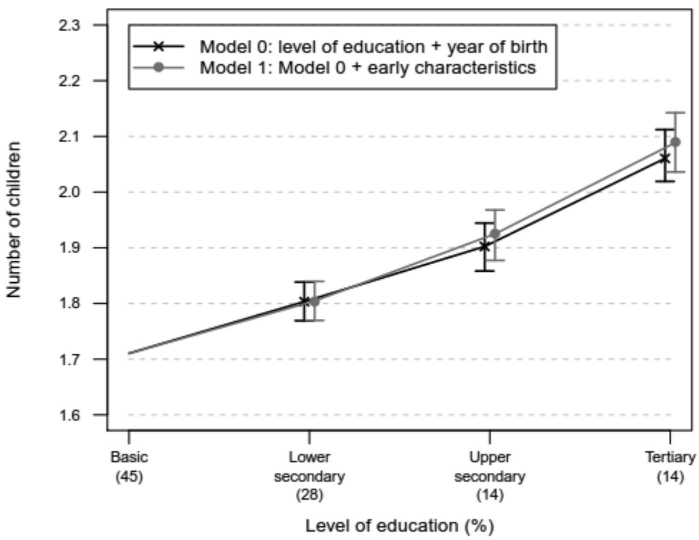

Figure 9 The number of children by level of education based on Poisson regression analysis, Finnish men born in 1940-50

Figure 8 (women) and Figure 9 (men) show the results on the number of children described above based on the IRRs proportional to the number of children in the data. The year-of-birth adjusted fertility of the basic-education group (1.93 in women and 1.71 in men) is taken as the point of reference. Accordingly, the lifetime number of children among women with a tertiary-level education was 1.72. Following adjustment for the early characteristics, the difference in the number of children between women with a tertiary and a basic education decreased from 0.21 to 0.15. The difference between women with an upper-secondary and a basic level of education was similarly attenuated, but remained unchanged among those with a lower-secondary educational level. Among the men, the educational gradient in the number of children indicating that those educated to the tertiary level had, on average, 0.35 more than those educated to the basic level, remained practically unaltered following adjustment for early characteristics.

5.2.2 THE EFFECT OF UNOBSERVED EARLY CHARACTERISTICS (II, III)

The analyses of the subsamples of women (Table 7) and men (Table 8) included in the sibling fixed-effects (FE) regression models are reported in this sub-section. Among the women, the association between the level of education and the number of children was weaker in the subsample (n=15,746) than in the full sample: the IRR of those with a tertiary level of education was 0.94 (95% CI 0.90, 0.98) (Model 0), whereas in the full sample and the corresponding model it was 0.89 (95% CI 0.87, 0.91). Figure 10 shows these results proportioned to the number of children: the fertility of women educated to the basic level in this sample adjusted only for year of birth was 2.00 children. Assuming this baseline fertility, an IRR of 0.94 corresponds to 0.11 children fewer for the women educated to the tertiary level compared to those with no more than a basic education. Adjusting for the observed early characteristics in this sample (Model 1) further reduced the association somewhat: the IRR of those with a tertiary education was 0.98 (95% CI 0.94, 1.02). The difference of 0.11 in the number of children fell to 0.05 (Figure 10). Finally and according to the point estimates, small differences were observable in the FE Model, which accounts for unobserved fixed family characteristics shared by sisters, although they were no longer statistically significant: the IRR of those educated to the tertiary level was 0.98 (95% CI 0.93, 1.05). This corresponds to a difference of only 0.03 in the number of children.

Table 7 also shows the corresponding FE regression analyses regarding having any children and the number of children beyond the first one for women. The educational gradient in the FE subsamples was attenuated in both outcomes compared to the whole sample. For having any children (n=4,491) the OR of those with a tertiary education was 0.86 (95% CI 0.74, 1.00) compared to those with a basic education, and including the observed early characteristics (Model 1) or unobserved fixed family characteristics (FE Model) hardly changed the gradient. In the case of the FE subsample for the number of children beyond the first one (n=11,569) the educational pattern was similar in direction to that in the whole sample: those with a tertiary education had as many children as those with a basic education (IRR 1.00 95% CI 0.93, 1.07) and those with a secondary education had the fewest. As in the whole sample of women here, too, adjustment for the observed early characteristics had an attenuating effect: the IRR of those with an upper-secondary education changed from 0.94 (95% CI 0.89, 1.01) to 0.98 (95% CI 0.92, 1.05). Adjustment for unobserved fixed family characteristics also attenuated the small educational differences in the number of children beyond the first one.

Among men, the association between education and the number of children in the subsample (n=16,691) included in the FE analysis was fairly similar to that in the full sample (Table 8). Figure 11 shows this proportioned to the number of children: the fertility of those educated to the basic level in this sample adjusted only for the year of birth was 1.84 children. Assuming this baseline fertility, an IRR of 1.17 corresponds to 0.31 children more for men educated to the tertiary level compared to those with no more than a basic education. The adjustment for observed early characteristics in this subsample (Model 1) had no attenuating effect on the estimates: in terms of the number of children, the difference between men educated to the basic and the tertiary level even rose slightly to 0.36. The inclusion of unobserved fixed family characteristics as shared by brothers had a similar effect (FE Model): the difference in the number of children was estimated at 0.35, and the differences between the basic and the other educational groups remained significant.

Still with regard to men, the corresponding FE models in the necessary subsamples were estimated for the other two fertility outcomes: having any children (n=5,875) and the number of children beyond the first one among fathers (n=11,569) (Table 8). In the former case, the association with education in the subsample was attenuated compared to the whole sample: the OR of those with a tertiary education was 1.65 (95% CI 1.42, 1.92). Adjustment for observed early characteristics increased some of the estimates. The FE model indicated that the educational gradient between brothers in having the first child was even larger than in the male sample on average, and there was no evidence of an explanatory role of unobserved early characteristics. For the number of children beyond the first, the association found in the subsample was similar to that in the whole sample: the IRR of those with a tertiary education was 1.07 (95% CI 1.01, 1.12). The inclusion of the observed characteristics slightly moved some of the estimates. The point estimates were fairly similar in the FE model as compared to Model 0 without the inclusion of observed characteristics, even if the confidence intervals were larger.

Table 7. *Lifetime fertility by level of education: standard and sibling FE analysis of the subsample used in the sibling FE analysis, Finnish women born in 1940–50*

Number of children[1]						
Model	0		1		FE	
Level of education	IRR	95%CI	IRR	95%CI	IRR	95%CI
Basic	1.00		1.00		1.00	
Lower secondary	0.95	(0.93-0.97)	0.95	(0.93-0.97)	0.97	(0.94-1.00)
Upper secondary	0.92	(0.89-0.96)	0.95	(0.91-0.99)	0.96	(0.91-1.00)
Tertiary	0.94	(0.90-0.98)	0.98	(0.94-1.02)	0.98	(0.93-1.05)
Having any children[2]						
Model	0		1		FE	
Level of education	OR	95%CI	OR	95%CI	OR	95%CI
Basic	1.00		1.00		1.00	
Lower secondary	0.90	(0.79-1.04)	0.91	(0.80-1.06)	0.91	(0.77-1.06)
Upper secondary	0.79	(0.67-0.93)	0.83	(0.69-0.99)	0.83	(0.68-1.04)
Tertiary	0.86	(0.74-1.00)	0.90	(0.74-1.07)	0.86	(0.69-1.11)
Number of children beyond the first[3]						
Model	0		1		FE	
Level of education	IRR	95%CI	IRR	95%CI	IRR	95%CI
Basic	1.00		1.00		1.00	
Lower secondary	0.94	(0.91-0.97)	0.94	(0.91-0.98)	0.97	(0.93-1.02)
Upper secondary	0.94	(0.89-1.01)	0.98	(0.92-1.05)	0.97	(0.90-1.05)
Tertiary	1.00	(0.93-1.07)	1.06	(0.98-1.15)	1.01	(0.92-1.11)

Model 0 : level of education and year of birth

Model 1: level of education, year of birth and early characteristics.

FE-model: level of education, year of birth and fixed family characteristics

[1] Method of analysis: Poisson regression, n=15,764.

[2] Method of analysis: binary logistic regression, n=4,491.

[3] Method of analysis: Poisson regression, n=11,569. Analysis on mothers only.

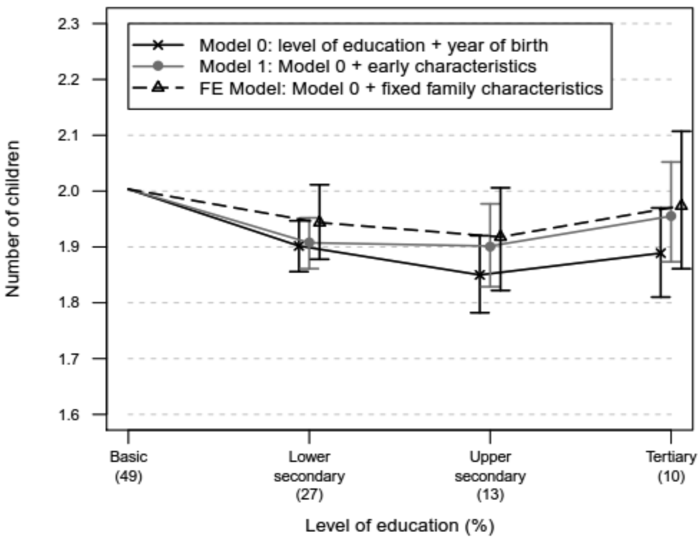

Figure 10 The number of children by level of education based on standard and sibling FE Poisson regression analysis, Finnish women born in 1940-50 (n=15,764)

Table 8. *Lifetime fertility by level of education: standard and sibling fixed-effects analysis of the subsample used in the sibling FE analysis, Finnish men born in 1940–50*

Number of children[1]						
Model	0		1		FE	
Level of education	IRR	95%CI	IRR	95%CI	IRR	95%CI
Basic	1.00		1.00		1.00	
Lower secondary	1.03	(1.00-1.06)	1.03	(1.01-1.06)	1.07	(1.03-1.11)
Upper secondary	1.10	(1.06-1.14)	1.12	(1.08-1.16)	1.11	(1.06-1.17)
Tertiary	1.17	(1.13-1.21)	1.19	(1.15-1.24)	1.19	(1.13-1.25)
Having any children[2]						
Model	0		1		FE	
Level of education	OR	95%CI	OR	95%CI	OR	95%CI
Basic	1.00		1.00		1.00	
Lower secondary	1.36	(1.21-1.52)	1.40	(1.25-1.57)	1.54	(1.34-1.76)
Upper secondary	1.51	(1.27-1.78)	1.69	(1.41-2.02)	1.97	(1.59-2.44)
Tertiary	1.65	(1.42-1.92)	1.97	(1.65-2.32)	2.44	(1.94-3.08)
Number of children beyond the first[3]						
Model	0		1		FE	
Level of education	OR	95%CI	IRR	95%CI	IRR	95%CI
Basic	1.00		1.00		1.00	
Lower secondary	0.95	(0.90-0.98)	0.95	(0.91-0.99)	0.97	(0.92-1.03)
Upper secondary	0.99	(0.94-1.05)	1.01	(0.96-1.08)	0.99	(0.92-1.06)
Tertiary	1.07	(1.01-1.12)	1.10	(1.04-1.17)	1.06	(0.98-1.14)

Model 0 : level of education and year of birth

Model 1: level of education, year of birth and early characteristics.

FE-model: level of education, year of birth and fixed family characteristics

[1] Method of analysis: Poisson regression, n=16,691

[2] Method of analysis: binary logistic regression, n=5,875.

[3] Method of analysis: Poisson regression, n=11,569. Analysis on fathers only.

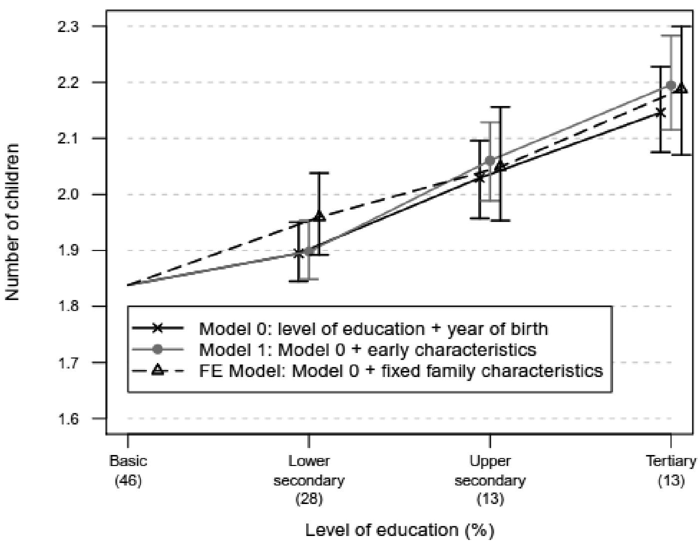

Figure 11 The number of children by level of education based on standard and sibling FE Poisson regression analysis, Finnish men born in 1940-50 (n=16,691)

5.2.3 THE EFFECT OF ADULT CHARACTERISTICS IN MEN (III)

The findings reported in this sub-section concern the mediating role of the other socioeconomic characteristics in adulthood and marriage in the association between level of education and lifetime fertility among men. Almost half of those in the studied male cohort were manual workers at the age of 30-34, and most (83%) had a history of marrying (Table 9). Occupational position and income showed clear positive associations with the number of children and with the likelihood of having any children. Men in the highest quintile accumulated 46-per-cent more children in their lifetime than those in the lowest quintile (IRR 1.46 95% CI 1.42, 1.50). Income was a strong predictor of having a first child, but the largest number of children beyond the first was, in fact, found among fathers with the lowest incomes. There was no significant difference between farmers and manual workers in the likelihood of having a first child, whereas conditional on having entered parenthood farmers had the largest numbers of children on average. Not surprisingly, having a history of marrying was a strong predictor of having children, and ever-married fathers also accumulated 33 per cent more children beyond the first one than the six per cent of never-married fathers in the cohort[15].

Table 9. *Lifetime fertility by adult characteristics (separate model for each character), controlled for year of birth, Finnish men born in 1940-50*

	N	%	N of children[1]		Having any children[2]		N of children beyond the first[3]	
			IRR	95% CI	OR	95% CI	IRR	95% CI
Occupational position								
Manual worker	17,430	47.0	1.00		1.00		1.00	
Lower white collar	6,845	18.5	1.11	(1.09-1.13)	1.82	(1.67-1.96)	1.01	(0.98-1.04)
Upper white collar	6,000	16.2	1.20	(1.17-1.22)	2.25	(2.06-2.47)	1.11	(1.08-1.15)
Farmer / self-employed	3,814	10.3	1.18	(1.15-1.22)	1.08	(0.99-1.18)	1.31	(1.26-1.35)
Other / unknown	2,993	8.1	0.73	(0.70-0.76)	0.34	(0.31-0.37)	1.05	(0.99-1.10)
Income								
1st quintile	7,417	20.0	1.00		1.00		1.00	
2nd quintile	7,416	20.0	1.22	(1.19-1.26)	2.77	(2.57-2.99)	0.88	(0.85-0.92)
3rd quintile	7,417	20.0	1.30	(1.26-1.33)	3.38	(3.13-3.66)	0.92	(0.89-0.96)
4th quintile	7,416	20.0	1.34	(1.30-1.38)	4.33	(3.96-4.70)	0.89	(0.86-0.93)
5th quintile	7,416	20.0	1.46	(1.42-1.50)	6.78	(6.14-7.44)	0.94	(0.91-0.98)
Marital history								
No	6,497	17.5	1.00		1.00		1.00	
Yes	30,585	82.5	3.93	(3.74-4.12)	31.34	(29.24-33.59)	1.33	(1.26-1.40)

[1] Method of analysis: Poisson regression.
[2] Method of analysis: binary logistic regression.
[3] Method of analysis: Poisson regression. Analysis on fathers only.

[15] Correspondingly, 12 per cent of all women and four per cent of mothers had never married, ever-married women accumulated four times more children than the never-married, and ever-married mothers accumulated 42 per cent more children after the first one than the never-married mothers. On the other hand, of childless men (women), 66 (56) per cent were never-married. In men, this share was inversely related to the level of education: 74 per cent of the basic educated versus 45 per cent of the tertiary educated childless were never-married.

Adjustment for adulthood occupational position (Model 2) and income (Model 3) clearly attenuated the differences by education in the number of children, by 41–68 per cent in total (Table 10). A weak positive association remained net of these adjustments, men with a tertiary education having eight-per-cent more children than those with a basic education. Accounting additionally for having ever married (Model 4) further reduced the education estimates such that only the men with a tertiary education had five-per-cent more children than those with a basic education. As Figure 12 shows, these results are proportioned to the numbers of children, the reference group being men educated to the basic level with a year-of-birth-adjusted fertility of 1.71. Before controls for any mediating characteristics men educated to the tertiary level had 0.37 children more than those in the reference group (Model 1). Adjustments for occupational position (Model 2), income (Model 3) and marital history (Model 4) reduced this difference to 0.22, 0.14 and finally to 0.09 children, respectively.

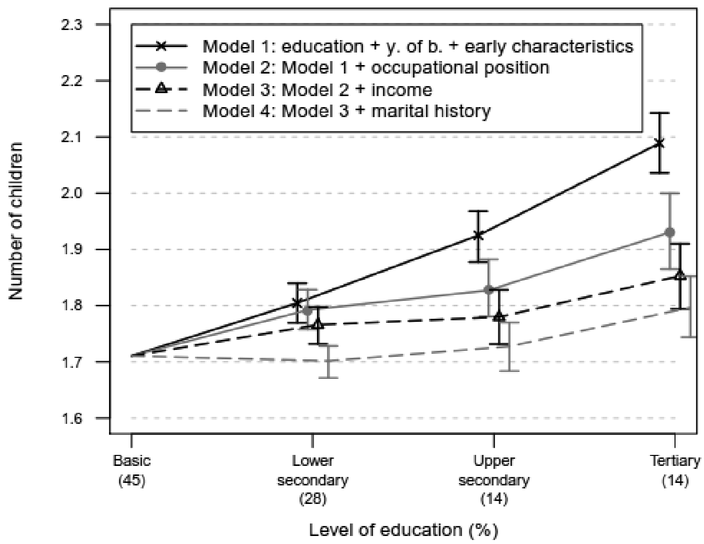

Figure 12 The number of children by level of education based on Poisson regression analysis, Finnish men born in 1940-50

Adjustment for occupational position (Model 2) as well as income (Model 3) strongly attenuated the educational differences in having any children (Table 10): the OR among men with a tertiary education dropped from 2.22 to 1.22 (95% CI 0.99–1.30). Net of having ever married (Model 4), no significant educational differences remained. Adjusting for occupational status and income (Models 2–3) had little effect on the estimates of education on fertility beyond the first child, as did adjustment for having a history of marriage.

An additional analysis showed that had marital history been adjusted for before any other adulthood characteristics the remaining IRR for the most-highly-educated group would have been 1.09 (95% CI 1.07, 1.12) for the number of children, the OR for having any children 1.36 (95% CI 1.21, 1.55), and the IRR for the number of children beyond the first 1.11 (95% CI 1.07, 1.15). The corresponding estimates for women were 0.95 (95% CI 0.92, 0.97), 0.62 (95% CI 0.55, 0.70), and 1.00 (95% CI 0.95, 1.04). These findings indicate that differences in ever having married do not completely mediate the educational differences in lifetime fertility among men or women.

Table 10. *Lifetime fertility by education without (Model 1) and with (Models 2-4) controls for occupational position, income and marital history, Finnish men born in 1940-50*

Number of children[1]								
Model		1		2		3		4
Level of education	IRR	95%CI	IRR	95%CI	IRR	95%CI	IRR	95%CI
Basic	1.00		1.00		1.00		1.00	
Lower secondary	1.06	(1.03-1.08)	1.05	(1.03-1.07)	1.03	(1.01-1.05)	0.99	(0.98-1.01)
Upper secondary	1.13	(1.10-1.15)	1.07	(1.04-1.10)	1.04	(1.01-1.07)	1.01	(0.98-1.03)
Tertiary	1.22	(1.19-1.25)	1.13	(1.09-1.17)	1.08	(1.05-1.12)	1.05	(1.02-1.08)
Having any children[2]								
Model		1		2		3		4
Level of education	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Basic	1.00		1.00		1.00		1.00	
Lower secondary	1.42	(1.33-1.52)	1.34	(1.25-1.43)	1.25	(1.17-1.33)	1.07	(0.98-1.16)
Upper secondary	1.84	(1.69-2.03)	1.34	(1.21-1.48)	1.19	(1.07-1.32)	1.00	(0.88-1.15)
Tertiary	2.22	(2.01-2.46)	1.40	(1.24-1.60)	1.12	(0.99-1.30)	0.91	(0.76-1.07)
Number of children beyond the first[3]								
Model		1		2		3		4
Level of education	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Basic	1.00		1.00		1.00		1.00	
Lower secondary	0.97	(0.94-0.99)	0.98	(0.95-1.00)	0.98	(0.95-1.00)	0.97	(0.95-1.00)
Upper secondary	1.00	(0.97-1.04)	1.02	(0.98-1.06)	1.02	(0.98-1.06)	1.01	(0.97-1.06)
Tertiary	1.12	(1.08-1.16)	1.11	(1.06-1.17)	1.11	(1.06-1.16)	1.10	(1.06-1.16)

Model 1: education, year of birth and early characteristics.
Model 2: Model 1 + occupational position.
Model 3: Model 2 + income.
Model 4: Model 3 + marital history.
[1] Method of analysis: Poisson regression.
[2] Method of analysis: binary logistic regression.
[3] Method of analysis: Poisson regression. Analysis on fathers only.

5.2.4 UNDERLYING GENETIC AND ENVIRONMENTAL FACTORS (IV)

Eighty-two per cent of the females and 77 per cent of the males in the Finnish twin cohort born in 1950-57 had one or more children, and 25 and 27 per cent, respectively, had more than two (Table 11). Twenty-five per cent of the women and almost 20 per cent of the men were educated at least to the senior-high-school level. In general, the association between the level of education and fertility was positive among the men and negative among the women (Table 12). These associations were not linear, however. On the question of having any children the difference among the women was mainly between those with and without a high-school education, whereas among the men, those with the least amount of education were the least likely to have children. There was also some nonlinearity in the estimates for having one to two or at least three children as opposed to no children, even if among the women those educated to the highest level had the lowest point estimates for all outcomes. Among the men, on the other hand, the point estimates indicated that having a larger number of children was somewhat more likely among those in the higher educational groups, but statistically it was mainly those with the least education who stood out from the other groups.

Given the nonlinearity found in the associations between education and fertility described above, the categories of education were adjusted for the behavioural-genetics analysis. Namely, the two lowest (52%) and the two highest (48%) educational groups classifying the women were collapsed, whereas the only distinction among the men was between the lowest level (primary school or less, 27%) and other (73%). In terms of fertility, the only distinction was between having and not having any children.

Table 11. *The distribution of the variables, Finnish female and male twins born in 1950-57*

	Women		Men	
	N	%	N	%
Lifetime fertility				
0	774	18	837	23
1–2	2,382	56	1,803	50
3+	1,072	25	952	27
Total	4,228	100	3,592	100
Level of education				
Primary school or less	1,151	27	972	27
More than primary school	1,033	24	1,305	36
Junior high school	971	23	631	18
Senior high school or more	1,073	25	684	19
Total	4,228	100	3,592	100

A modest tetrachoric correlation in the expected direction was found between education and having any children among both women (−0.18; 95% CI = −0.23, −0.17) and men (0.13; 95% CI = 0.06, 0.20). The numbers of concordant and discordant MZ and DZ twin pairs (in terms of education/fertility) and the tetrachoric correlations of MZ and DZ twin pairs (for education/fertility) are shown in Table 13. A larger proportion of MZ than DZ twin pairs was concordant for both education and fertility, and the tetrachoric correlations were also higher, suggesting genetic influences on the two traits under investigation. The correlations in the DZ twin pairs were relatively weak for having any children, but more than half of those of the MZ pairs for education, suggesting common environmental effects on education but not on having any children.

In the best fitting bivariate behavioural-genetics model the common environmental component for having any children and the common environmental and unique environmental correlations for education and having any children were dropped for women ($\Delta\chi^2_3$=6.9, p=0.07, ΔAIC=0.97) and men ($\Delta\chi^2_3$=0.103, p=0.99, ΔAIC=-5.897). According to the best fitting bivariate models for education and having any children (Table 14), education in women depended on genetic (a^2 0.41), common environmental (c^2 0.54) and, to a minor extent, unique environmental factors (e^2 0.05). Educational variance was estimated to result similarly from genetic (a^2 0.42) factors among the men, whereas common environmental factors (c^2 0.37) had a smaller, and unique environmental factors (e^2 0.21) a larger effect. The sources of variance in having any children were estimated as genetic factors (female a^2 0.39, male a2 .50) and environmental factors unique to the twins (female e^2 0.61, male e^2 0.50). According to these models, there was a correlation between the genetic factors of education and having any children (female r_a -0.44, male r_a 0.28).

Table 12. *Lifetime fertility by level of education (controlled for year of birth), Finnish female and male twins born in 1950-57*

	Women				Men			
	Having any children[1]				Having any children[1]			
Level of education	OR	95%CI			OR	95%CI		
Primary school or less	1.00				1.00			
More than primary school	1.01	(0.79-1.30)			1.62	(1.33-1.97)		
Junior high school	0.61	(0.49-0.78)			1.61	(1.25-2.08)		
Senior high school or more	0.56	(0.44-0.69)			1.40	(1.11-1.78)		
	One or two[2]		Three or more[2]		One or two[2]		Three or more[2]	
Level of education	RRR	95%CI	RRR	95%CI	RRR	95%CI	RRR	95%CI
Primary school or less	1.00		1.00		1.00		1.00	
More than primary school	1.07	(0.83-1.38)	0.91	(0.68-1.20)	1.75	(1.42-2.16)	1.38	(1.08-1.76)
Junior high school	0.63	(0.50-0.81)	0.58	(0.44-0.76)	1.61	(1.23-2.11)	1.61	(1.19-2.18)
Senior high school or more	0.58	(0.46-0.73)	0.51	(0.39-0.67)	1.32	(1.03-1.70)	1.55	(1.16-2.06)

[1] Reference category: No children. Method : binary logistic regression.

[2] Reference category: No children. Method: multinomial logistic regression.

Table 13. *Twin-pair resemblance in level of education and having any children, Finnish female and male twins born in 1950-57*

	Women					Men				
	Concordant		Discordant	ρ	95% CI	Concordant		Discordant	ρ	95% CI
	-/-	+/+	-/+			-/-	+/+	-/+		
Number of MZ pairs										
Education[b]	250	275	58	0.95	(0.92-.097)	56	297	65	0.78	(0.67-0.86)
Having any children	37	416	130	0.41	(0.26-0.55)	37	288	93	0.51	(0.35-0.65)
Number of DZ pairs										
Education[b]	506	458	285	0.75	(0.70-0.80)	153	627	255	0.59	(0.54-0.66)
Having any children	59	857	333	0.20	(0.09-0.31)	80	630	325	0.22	(0.11-0.33)

[1] Education refers to at most more than primary school (52%) versus high school or more (48%).

[2] Education refers to primary school or less (27%) versus at least more than primary school (73%).

Finally, for comparative purposes a bivariate genetic model was constructed for the association between education and AFB. Because this association turned out to be linear, both of the variables were used as continuous. The correlation between them was moderate among the women (0.35 95% CI .32, .39) and modest among the men (0.23 95% CI .18, .27). The genetic factors for AFB and the genetic and unique environmental correlations between education and AFB among men ($\Delta\chi^2_3$=3.0, p=0.40, ΔAIC=-3.04) were dropped in the best fitting models (Table 15), whereas among women all the parameters were statistically significant. According to these models, among women education resulted from genetic factors (a^2 0.46) and common (c^2 0.38) and unique (e^2 0.16) environmental factors. Male variance in education was respectively attributable (a^2 0.36, c^2 0.46, e^2 0.19). In the case of AFB, genetic factors (a^2 0.26), and common (c^2 0.12) and unique (e^2 0.61) environmental factors were all significant among the women, whereas the sources of male variance were common (c^2 0.22) and unique (e^2 0.78) environmental factors. Genetic (r_a 0.27), common environmental (r_c 1.00) and unique environmental (r_e 0.14) factors all correlated among the women, as opposed to only common environmental factors among the men (r_c 0.68).

Table 14. *Estimates of variance components for education and having any children and correlations between them from bivariate Cholesky decomposition, Finnish female and male twins born 1950-1957*

	Women				Men			
	Education[1]		Having any children		Education[2]		Having any children	
Variance components								
Genetic (a^2)	0.41	(0.33-0.52)	0.4	(0.29-0.49)	0.4	(0.17-0.65)	0.5	(0.37-0.62)
Common environmental (c^2)	0.54	(0.45-0.63)	na		0.4	(0.19-0.55)	na	
Unique environmental (e^2)	0.05	(0.03-0.08)	0.6	(0.50-.74)	0.2	(0.13-0.31)	0.5	(0.38-0.63)
Correlations between variance components								
r_a	-0.44	(-0.63 - -0.28)			0.3	(0.13-0.51)		
r_c	na				na			
r_e	na				na			

Intervals in brackets in this table refer to 95% confidence interval.
Parameter estimates marked as na are constrained to zero in the best fitting model shown in this table.
[1] Education refers to at most more than primary school (52%) versus high school or more (48%).
[2] Education refers to primary school or less (27%) versus at least more than primary school (73%).

Table 15. *Estimates of variance components for education and AFB and correlations between them from bivariate Cholesky decomposition, Finnish female and male twins born 1950-1957*

	Women				Men			
	Education[1]		AFB		Education[1]		AFB	
Variance components								
Genetic (a^2)	0.46	(0.39-0.53)	0.3	(0.09-0.37)	0.4	(0.28-0.44)	na	
Common environmental (c^2)	0.38	(0.32-0.45)	0.1	(0.06-0.24)	0.5	(0.38-0.53)	0.2	(0.16-0.28)
Unique environmental (e^2)	0.16	(0.14-0.18)	0.6	(0.55-0.69)	0.2	(0.16-0.22)	0.8	(0.72-0.85)
Correlations between variance components								
r_a	0.27	(0.03-0.50)			na			
r_c	1.00	(0.68-1.00)			0.7	(0.55-0.84)		
r_e	0.14	(0.05-0.23)			na			

Intervals in brackets in this table refer to 95% confidence interval.
Parameter estimates marked as na are constrained to zero in the best fitting model shown in this table.
[1] Education is used as a continuous variable.

6 DISCUSSION

6.1 INTERPRETATION OF THE MAIN RESULTS

6.1.1 FERTILITY PATTERNS BY GENDER, AGE AND EDUCATION

Finnish men educated to higher levels were found to have lower levels of childlessness and higher lifetime numbers of children, confirming previous findings from the Nordic countries (Fieder & Huber, 2007; Goodman & Koupil, 2009; Kravdal, 2007; Kravdal & Rindfuss, 2008; Lappegård et al., 2011; Rønsen & Skrede, 2010), including Finland (Nikander, 1995). According to a recent comparative study on 19 European countries, childlessness at the age 40-44 is more common among men with a lower level of education in 13 of them (Miettinen et al., 2015). In the birth cohort investigated in the present study, men educated to the tertiary level had over two children on average (2.06), whereas those not educated beyond the basic level had less than two (1.71), the difference amounting to 0.35 children.

In terms of parities this was largely attributable to having a first child, which explained three quarters of the difference between the tertiary and the basic-education groups. It thus seems that childlessness, which is relatively common (24%) among men with the lowest level of education, is a major factor in explaining lifetime fertility differences between educational groups in men. This lends support to findings on reproductive success in Sweden showing that educational differences vanish when the childless are excluded (Fieder & Huber, 2007). It was further found in the present study that progress to the second parity increased these differences in Finland, even if less strongly. Nordic studies indicate increasing levels of childlessness across male cohorts, but no weakening trend in terms of social differentials therein (Lappegård et al., 2011; Miettinen et al., 2015; Rønsen & Skrede, 2010) or in the number of children (Kravdal & Rindfuss, 2008). One third of Finnish men born in the early 1960s and with a basic level of education were childless at the age of 40-44 (Väestöntutkimuslaitos, 2015).

In terms of age-specific fertility, the higher lifetime number of children among the more highly educated men resulted from higher fertility rates from the age of 26, whereas at younger ages the rates were higher among those educated to the basic level. This was not unexpected given that acquiring higher levels of education has also been associated with the postponement of parenthood among men in various contexts (Corijn & Klijzing, 2001; Kiernan & Diamond, 1983; Kneale & Joshi, 2008; Liefbroer & Corijn, 1999; Winkler-Dworak & Toulemon, 2007; Zhang, 2011). The age-specific patterns in the Finnish data were qualitatively similar in both genders, although the differences between educational groups at young ages were much larger among the women. These results may, to some extent, reflect the fact that men also have low fertility rates during educational enrolment, but the effect is probably less pronounced than among women (Dribe & Stanfors, 2009; Kravdal, 2007; Thalberg, 2013). Previous Nordic evidence also tends to indicate that the effect of educational level on first births, net of enrolment, among men is more positive at older ages (Dribe & Stanfors, 2009; Jalovaara & Miettinen, 2013; Kravdal, 2007; Lappegård & Rønsen, 2013).

On the cumulative level in the present study, there were proportionately more fathers among men with a tertiary compared with a basic education from the age of 29 onwards, and cumulative fertility was similarly higher in the early thirties and beyond. It was also found that 95 per cent of the educational gradient in the lifetime number of children was reached at the age of 45. It may be that measurement at younger ages underestimates some of the differences and that measurement up to this age may be sufficient to capture almost the whole educational gradient in male fertility. However, given the changes in fertility across cohorts (Kravdal & Rindfuss, 2008; Lappegård et al., 2011; Rønsen & Skrede, 2010), the validity of this result cannot be taken for granted among younger cohorts.

The gender difference in educational gradient with regard to age-specific fertility at a relatively young age, before the mid-twenties, largely accounted for the gender difference in the lifetime number of children by education. In the Finnish cohort born in 1940-50, women educated to higher levels were more likely than their male counterparts to remain childless and to have a lower lifetime number of children, amounting to an average, although smaller difference (0.21) between the tertiary (1.73) and the basic (1.93) levels. A previous Finnish study noted that remaining childless largely explained negative differences in the number of children among women (Ilmakunnas, 1994). Among younger cohorts of Finnish women, however, those educated to the middle level appear to accumulate the highest numbers of children on average, and to have lower levels of childlessness than those educated to the lowest and highest levels (Andersson et al., 2009; Pajunen, 2013; Ruokolainen & Notkola, 2007).

The later-age fertility patterns of the women and men born in 1940-50 studied here were more similar with respect to education. Men in their late thirties and early forties had higher age-specific fertility rates than their female counterparts, but the absolute differences between educational groups were of a similar magnitude. These age-specific patterns are in line with previous findings on women showing that fertility recuperation among more-highly-educated groups contributes to the relatively high cohort fertility and modest social differentials therein in the Nordic countries (Andersson et al., 2009; Frejka & Calot, 2001); for first births see also (Kravdal, 1994; Lappegård & Rønsen, 2005; Tesching, 2012). Previous studies on Finnish women have also highlighted the age-dependency: net of the negative effect of enrolment, educational level has been positively associated with fertility rates among women aged 30 and over, whereas among younger women those educated to the lowest level had the highest rates of entering parenthood (Vikat 2004; Jalovaara and Miettinen 2013; see however Berninger, 2013).

Higher-parity fertility in this study was measured as the number of children born to parents after the first one. The corresponding results reveal relatively small educational differences in higher-parity fertility, particularly among women. It may be that the gender differences are smaller with respect to higher-parity fertility than in terms of the first child. This corresponds to the age-specific pattern described above: early fertility, dominated by first births, explained most of the gender-difference in the educational gradient in lifetime fertility, a U-shaped pattern in the number of children born after the first one emerging in both. The implication is that, conditional on having a first child, a higher education does not necessarily prevent women from having more children, nor does it strongly reinforce subsequent fertility in men. Indeed, when age at having the first child is controlled for, highly educated women in the Nordic countries show higher rates of second and third births (Berinde, 1999; Gerster et al., 2007; Hoem & Hoem, 1989; Kravdal, 1992; Kravdal, 2001; Kravdal, 2007; Kravdal & Rindfuss, 2008; Oláh, 2003; Tesching, 2012; Vikat, 2004). The few studies on Nordic men generally report positive effects (Kravdal, 2007; Lappegård & Rønsen, 2013; Oláh, 2003). A positive association has been reported among Swedish and Norwegian couples between both maternal and paternal levels of education and second- and third-birth rates (Duvander & Andersson, 2006; Duvander et al., 2010).

Moreover, the results of the present study indicate that fertility tempo and quantum may vary more among men with lower levels of education: the more highly educated, on average, had their children not only later but also within a shorter age-span. This may reflect the differences in parity composition to some extent: both staying childless and going on to have three or more children were relatively common among the less highly educated. Regardless of the parity composition, the timing of the different parities may also contribute to the overall fertility-timing pattern. Indeed, the timing of the second and third births also varied more among the less highly educated. The implication is that educational differences in parity composition do not fully explain the overall fertility-timing pattern reported here. Men educated to a low level were less likely to remain in an intact marriage over their life course, which may relate to the dispersion in fertility timing attributable to unexpected life events such as divorce (Lyngstad & Jalovaara, 2010) or unplanned births (Nelson, 2004).

6.1.2 THE EFFECT OF EARLY AND ADULT CHARACTERISTICS ON EDUCATIONAL DIFFERENCES

Socioeconomic and demographic characteristics observed early in life predicted men's and women's fertility differently in the Finnish cohort born in 1940-50, in particular with respect to having a first child. Not unexpectedly (Dahlberg, 2015; Lappegård & Rønsen, 2005; Nikander, 1992), women with an affluent family background such as those whose parents were educated to a relatively high level, ended up with lower lifetime fertility. On the other hand, sons whose parents had a low-level education and lived in less advantaged circumstances in childhood accumulated fewer children in their lifetime. Remaining childless played an important role here: conditional on having the first child, some adverse early-life indicators predicted even slightly higher fertility in men. These findings resemble results concerning older Swedish cohorts indicating that a higher family socioeconomic position predicted higher reproductive success among men but not women (Goodman & Koupil, 2009). No differences were found in the eventual likelihood of fatherhood by parental education among younger Swedish cohorts, however, despite a negative effect on timing (Dahlberg, 2015). Other previous Nordic studies indicate a negative or null effect of parental education on first birth, and a positive one on higher-order birth rates among men (Dribe & Stanfors, 2009; Lappegård & Rønsen, 2013). As expected (Kolk, 2014; Murphy & Knudsen, 2002; Pouta et al., 2005), higher fertility was characteristic of those with more siblings, and of women (Kulu et al., 2007; Nikander, 1992) with an agricultural background. Among men, on the other hand, those with an agricultural background were relatively more likely to remain childless or to have a large number of children. These results highlight gender differences, and parity-specific differences in the case of men, with respect to early life socioeconomic predictors of lifetime fertility. However, if the effects of these characteristics were somewhat mediated by individual status (Dahlberg, 2015; Kolk, 2014), an issue that was not assessed thoroughly in this study, they might be sensitive to changes in relations between individual status and fertility across cohorts.

The results of this study indicate that even a detailed measurement of socioeconomic and to some extent demographic (number of siblings, family type and living area) characteristics in early life does not explain away educational differences in lifetime fertility, in this case as witnessed in the Finnish cohort born in 1940-50. No explanatory role of such characteristics was found among the men. Among the women, adjustment for early characteristics, mainly parental education and occupational status, explained differences in the lifetime number of children to a moderate degree, by 3-28 per cent. This implies that life goals other than family building, such as having a career, may be emphasised more strongly in families in which the parents have a higher socioeconomic status (Rijken & Liefbroer, 2009; Scott, 2004) – in some cases at the cost of higher fertility. These findings are consistent with those reported in other Nordic studies based on event-history methodology indicating, net of adjustment for background factors such as the number of siblings, parental class and the level of urbanisation in childhood, educational-level differences in first- and higher-order birth rates among women (Dribe & Stanfors, 2009; Kravdal, 1994; Kravdal, 2007; Kravdal & Rindfuss, 2008;

Lappegård & Rønsen, 2005)[16] and men (Kravdal, 2007; Kravdal & Rindfuss, 2008; Lappegård & Rønsen, 2013). However, previous quasi-experimental studies conducted in Norway (Monstad et al., 2008) and Sweden (Skirbekk et al., 2006) report educational effects on timing but not on the number of children among women.

Sibling fixed-effects (FE) analyses, which by design account for unobserved characteristics shared by siblings, were conducted in addition to the analyses controlling for the observed early-life characteristics. The interpretation of these results was complicated by the fact that families with more than one same-sex sibling and varying fertility outcomes, particularly in the case of the first child, were a somewhat select group. This is shown in the smaller sizes, higher-than-average fertility and lower educational composition (in women) of the subpopulations analysed in the sibling FE analyses than in the corresponding total samples. The potentially higher internal validity of the FE analysis may have come at the cost of external validity. Overall, the results of these analyses appear to support the interpretations based on adjustment for observed early characteristics described above.

The implications of these findings are at least two-fold. First, it is plausible that sibling FE analyses control well for long-term parental class and other structural conditions in the family of origin, but they may not entirely capture more sensitive differences between siblings related to family-related life-cycle changes and resource allocation, interaction between siblings or genetic relatedness, for example (Kohler et al., 2011; Sigle-Rushton, Lyngstad, Andersen, & Kravdal, 2014). Unobserved and uncontrolled within-family variation, in other words systematic differences between same-sex siblings that influence both education and fertility, may still bias within-family estimates. Second, the results indicate that failing to control for early socioeconomic and demographic characteristics in studies on educational differences in lifetime fertility may not overestimate the differences among men. The corresponding bias among women may be moderate, depending on the fertility outcome in question. However, controls for parental socioeconomic position should be included whenever possible in studies assessing the effect of education on lifetime fertility among women to overcome the problem of confounding. Overall, given the available background measures, the analyses indicate that among men in particular, causal mechanisms in adulthood may be more relevant in explaining educational differences in lifetime fertility than spurious mechanisms arising from early-life characteristics.

Measures of male occupational status and income were used to assess the mechanisms linking education and fertility related to labour-market resources in adulthood. Occupational status could be considered a more proximate measure of attachment to the labour market and earning potential than

[16] Dribe and Stanfors (2009) studied first birth rates at young ages among women and men in Sweden, and found no differences by educational level among the men.

education (Begall, 2013). Income measures actual earnings and is a strong indicator of economic resources in general (Elo, 2009). Occupational position and income were positively related to having a first child, and to the overall number of children, in the Finnish male cohort born in 1940-50. Previous studies from other Nordic countries have also reported positive effects of income and attachment to the labour market on entering parenthood (Dribe & Stanfors, 2009; Hart, 2015; Kravdal, 2002; Lappegård & Rønsen, 2013). It has been found previously with regard to Finland that male childlessness is common among manual workers and farmers (Nikander, 1995; Pajunen, 2013); that fixed-term employment postpones fatherhood but does not affect ultimate childlessness (Sutela, 2013); and that socioeconomic resources increase the first-birth rate among couples (Jalovaara & Miettinen, 2013). In this study, however, fathers with the lowest income levels had the highest number of children beyond the first one. Similarly, despite the relatively common childlessness among farmers, fathers in this category had the largest families. Previous Finnish studies report the highest average numbers of children among upper-white-collar employees and the self-employed (excluding farmers) (Nikander, 1995; Pajunen, 2013), whereas farmer couples have the highest and manual-worker couples the lowest numbers of children (Erola, 2010).

Adjustment for occupational status and income diminished the estimated effects of education on the lifetime number of children by as much as 41-68 per cent. This mediating effect was also strong for having a first child, but not for fertility in higher parities. These results imply that economic mechanisms, such as the income effect (Becker, 1993a), provide more relevant explanations of the educational differences in having a first child, whereas other explanations may account for the moderate differentials in higher-parity fertility among men. The findings on higher-order births resemble earlier results from other Nordic countries showing that two-child fathers with weak attachment to the labour market (Andersson & Scott, 2007; Kravdal, 2002; Kreyenfeld & Andersson, 2014) and couples with low total earnings are more likely to have a third child (Duvander & Andersson, 2006; Duvander et al., 2010). Second births (Kravdal, 2002) and higher-order births in total (Lappegård & Rønsen, 2013) have nevertheless been associated with a good economic standing in Norway. Following further adjustment for marital history, no significant differences remained in having a first child. This is indicative of the close relationship between union formation and fertility, in particular first births, among men (Berrington & Pattaro, 2014). Given that men's socioeconomic resources tend to increase their chances in the marriage market (e.g. Jalovaara, 2012), this result is not unexpected.

6.1.3 GENETIC AND ENVIRONMENTAL SOURCES OF EDUCATIONAL DIFFERENCES

The results of this study based on the Finnish twin cohort born in 1950-57 confirmed earlier findings on the underlying genetic component of fertility (Kohler et al., 2006; Mills & Tropf, 2015). The likelihood of having a first child was influenced by underlying genetic sources and environmental sources unique to twins within families, but not by environmental sources common to twins. The variance estimates were roughly in line with previous evidence (Kohler and Christensen 2000; Kohler et al. 1999) implying that genetic effects and unique environmental effects explain variation among men fairly evenly, whereas the proportion of genetic variance among women appears to be smaller. The level of education, in turn, turned out to be influenced by underlying genetic factors and environmental factors that are common and, to a smaller extent, unique to twin siblings. Studies from other countries on the variance in educational levels higher than those investigated here, however, report higher estimates of unique environmental variance (Kohler and Rodgers 2003; Neiss et al. 2002; Rodgers et al. 2008; Silventoinen et al. 2004).

The behavioural-genetics analysis of the covariance between educational level and the chance of having a first child revealed that the negative association in women and the positive one in men were influenced by underlying genetic factors. This finding gives new insight into the association among men in particular. These results differ from those reported in a previous study on Danish twins focusing on the association between educational level and the number of children: there was minimal overlapping of genetic variance, and the association was mainly modelled as common environmental covariance among women and men (Kohler and Rodgers 2003). Then again, the results of this study resemble those reported in a previous study on US women in which the basic bivariate genetic model (closest to the bivariate model in this study) identified genetic and weaker unique environmental covariance but no significant common environmental covariance contributing to the association between education and the number of children in women (Kohler et al. 2011).

The genetic correlation between educational level and the chance of having a first child may indicate either that the same genetic factors influence both education and fertility directly, or that genetic factors influence fertility indirectly through education (Kohler et al 2011). The former option would imply a spurious association between educational level and having a first child, whereas the latter allows causal effects between education and fertility. The two options need not to be mutually exclusive. Plausible individual characteristics that mediate the role of underlying genetic factors in the process in which the documented education-fertility relationships emerge may include cognitive abilities, personality traits and health, all of which have previously been associated with fertility or closely-related outcomes (Fu &

Goldman, 1996; Miller, 1992; Retherford & Sewell, 1989); for a related discussion on genetic causes in social sciences see (Freese, 2008).

The findings from this study based on a Finnish population sample of women and men born in 1940-50 could, even if with reservations (Kohler et al., 2011), imply that indirect background effects may be stronger than direct effects suggesting a spurious association, among men at least. Kohler et al., (2011) concluded in the above-mentioned study on US female twins that the genetic correlation between educational level and the number of children primarily arises from indirect genetic influences through education on fertility, thereby implying a mediating effect of education on fertility (Kohler, 2011). It was reported in another US twin study on monozygotic female twins based on FE analyses that, education had no effect on the likelihood of having a first child, but it had an effect on the timing and on the number of children (Amin, 2015). It has previously been reported in economics literature focusing on changes in compulsory-schooling laws that education influences the timing of the first child, but the evidence is less consistent across different cultural contexts on the effect of education on the number of children (see Fort et al., 2014 and the references therein).

The results of this study on the underlying sources of the association between educational level and the chance of having a first child were compared with respective findings concerning the association between educational level and AFB. First, the variation in AFB was largely attributed to environmental factors that are unique to twins, and to a lesser extent to common factors. Genetic factors were significant among women but not among men. Previous evidence on the underlying sources of variance in AFB is mixed and largely based on women: studies from Denmark (Rodgers, 2008) and the US (Neiss, 2002) report little or no genetic variance but wider common environmental variance, whereas estimates that are similar in magnitude to those related to women in this study were found in a study conducted in the UK (Tropf et al., 2015). The association between educational level and AFB was modelled as common and unique environmental and genetic covariance in women, whereas only the common environmental correlation was significant among the men. Covariance has previously been modelled as common environmental and genetic covariance in the US (Neiss et al., 2002), and as common environmental covariance only among women in Denmark (Rodgers et al., 2008). It was further reported in these studies that education mediated the effect of intelligence on AFB, but the effect lost its significance when latent factors were included in the model.

The gradual postponement of parenthood is considered a major route to remaining childless, at least among women (Kemkes-Grottenthaler, 2003; Rowland, 2007; Toulemon, 1996). In general, the timing and the chances of having a first child are thought to have common determinants (see e.g. Sobotka, 2004). The differing estimates of educational covariance with the timing and the chance of having a first child reported in this study could therefore potentially indicate that the latter is influenced to some extent by low (co)variance and/or statistical power, which is why the results should be interpreted with some caution. On the assumption that the difference between the two fertility outcomes is not merely a methodological artefact, however, the following interpretations are possible. The unique environmental correlation among women indicates that, irrespective of any influences stemming from the family of origin, further education may postpone motherhood, but does not affect the eventual chance of motherhood. The gender difference in the timing of the first child, the covariance in men appearing to stem only from environmental factors shared by twins, could thus be interpreted to signal that a woman's life-course situation matters more than a man's in this respect.

Although there was no evidence that environmental factors shared by twins influenced the chance of having a first child, interaction effects between genetic predispositions and social environments are possible (Kohler et al., 1999; Udry, 1996). By default, all interaction effects between genetic and common environmental effects, observed as higher resemblance among MZ than DZ twin pairs, are modelled as genetic variance (Neale and Cardon 1992: 22–23). In this light, the associations found between early-life-course variables and fertility in the Finnish population sample, as described earlier, may in some cases arise from gene-environment interactions. It has been argued that biologically based traits in interaction with experiences during childhood, youth and adulthood may produce the motivation to have children (Miller, 1994; Miller, 1992).

6.2 METHODOLOGICAL CONSIDERATIONS

The strengths of this study include the two unique data sets on which it was based. The first one, which was derived from the 1950 Census in Finland with linkages to later registers, allowed the identification of family members in 1950 and therefore the non-retrospective measurement of early-life conditions and sibling comparisons. It also facilitated follow-up from the early-life stages over the reproductive age span among both women and men. The measurement of fertility could be considered satisfactory. The fact that children born before 1970 are not fully covered for a parent they did not live with at the time of the population census in 1970 may introduce selective bias in the fertility measurement for men, however (Nelson, 2004). With regard to the 1970 census, women born in the early 1940s with a low level of education were more likely to be living alone with children. According to a survey of women, however, only five per cent of children were born out of wedlock in the period 1966-1970 (Finnäs, 1993). Thus any such bias would probably have only a marginal influence on the findings.

The second set comprising twin data derived from the older cohort of the Finnish Twin Cohort Study offered an exceptional opportunity to analyse the role of underlying genetic and environmental factors in associations between education and fertility in the comparatively large twin sample. The measurement of fertility was also based on register data, and as in the first data set was also potentially subject to the underestimation of children among men. Any such bias is likely to be smaller than for the first data set, however, because this one is based on later birth cohorts. According to a previous estimate, the proportion of children aged 0–17 years without a known father in the year 1997 was 1.3 per cent (Kartiovaara & Säkkinen, 2007), thus any underestimation should only marginally affect the findings.

Given that the measurement of education in this study was not time-variant, it was not possible to measure current educational levels, or to distinguish between the effects of enrolment and attainment in the analysis. In sub-studies I-III educational attainment was measured at the age of 30-34, by which time most people have finished their education (8% of the women and 5% of the men achieved a higher level at the age of 45–49). In terms of fertility levels at the age of 30, women had achieved 77 per cent and men 64 per cent. In reality, however, the birth cohort under study tended to finish their education long before they reached the age of 30-34. Close to half of the sample had no more than a basic level of education, which tends to be achieved at the age of 16. It can therefore be assumed that in most such cases attainment of the highest educational level preceded fertility, hence the study design should not be susceptible to severe weaknesses related to anticipatory analysis (Hoem & Kreyenfeld, 2006). The imputation of educational histories was not considered as an alternative: according to a previous study it may not offer a satisfactory solution to the problem of missing data on complete educational histories (Kravdal, 2004).

In the opinion of Hoem and Kreyenfeld (2006), measuring educational level at a time point when most people have finished their education corresponds to inherently assuming that attainment is a fixed individual characteristic and a strong indicator of a lifelong plan. Using final instead of current education may produce different results: more negative associations between education and fertility in women, for example, at least in the context of a flexible educational system (Kravdal, 2007). In addition, the level of education is measured somewhat differently in sub-studies I-III than in sub-study IV. In the twin data set the measurement was carried out at a younger age (28 years in most cases) and the measure places more emphasis on academic education in relation to vocational education than the measure used in sub-studies I-III. For example, the highest qualification in sub-study IV (senior high school or more) requires an academic high-school diploma. Correspondingly, the highest category in sub-studies I-III (tertiary) includes those who followed the vocational track to the highest level irrespective of their academic education.

It is generally assumed in this study that reverse causality, from fertility to education, is less important than causality from education to fertility (e.g. Blossfeld, 1995; Rindfuss et al., 1980). This assumption is open to criticism based on earlier empirical findings, however (e.g. Cohen et al., 2011). Given the use of a non-time-varying measurement of education, the possibility of reverse causality cannot be ruled out (Hoem & Kreyenfeld, 2006; Kravdal, 2004; Kravdal, 2007). Endogeneity is a potential problem attributable to missing variables, but it can also arise because of simultaneous effects of education on fertility, and vice versa (Moffitt, 2005). There is also a possibility of reverse causality in the relationship between income and fertility among men as assessed in sub-study III, attributable to the need to support a family, for example (Gupta, Smith, & Stratton, 2007; Lundberg & Rose, 2002).

An additional analysis on a subsample of women excluding those who had their first child before the age of 20 (15% of mothers) indicated that births at a young age were strong in determining the educational gradient in the lifetime number of children. The educational differences in fertility were not statistically significant in this subsample (n=30,884): the year-of-birth controlled IRR of those educated to the tertiary level was 0.98 (95%, CI 0.96, 1.01) compared to those with a basic education. Given that the women in this birth cohort finished their education at a relatively young age, this cannot be considered evidence of reverse causality as such. However, given the likelihood that a large proportion of births at younger ages are unplanned (Henshaw, 1998; Vikat et al., 2002), unplanned births may have contributed to the negative gradient in lifetime fertility among Finnish women born in the 1940s.

The aim in applying a study design based on families and twins was to overcome the problem of omitted variables and to provide new information on the underlying genetic and environmental factors in the association between education and lifetime fertility among women and men. As Moffitt (2005) expressed it, it was done in an attempt to improve the internal validity of the analysis at the potential cost of a loss of external validity. Twins experience a special family environment in childhood: they always have at least one sibling of the same age. This may relate to their fertility desires (Murphy & Knudsen, 2002) and may also have affected resource allocation in their family of origin (Booth & Kee, 2009). The question of external validity also concerns the sibling FE analysis, which was based only on those with at least one same-sex sibling who had a different fertility outcome than the other sibling(s). It was shown earlier that fertility was higher in the analytical sample than in the population sample.

With regard to internal validity, the sibling FE approach relies on the assumption that siblings are better controls for each other than individuals picked at random, in other words the comparison of siblings comes closer to a counterfactual situation in which different values of the same individual are compared in the ideal case, rather than different values of different individuals (Moffitt, 2005). A previous Swedish study indicated that sibling fertility is correlated (Dahlberg, 2013). It could therefore be assumed that the sibling FE method helps to overcome the problem of omitted variables in controlling for characteristics that siblings share and that influence their fertility (Ribar, 1999). This assumption has also been criticised, however, given the evidence that unobserved and uncontrolled within-family heterogeneity still causes bias in associations between teenage fertility and later outcomes (Holmlund, 2005). In general, family FE models may be sensitive to the inclusion of additional controls on characteristics that differentiate siblings (Sigle-Rushton et al., 2014).

An additional point concerning validity is that siblings may influence each other in ways that are relevant to their fertility: there is empirical evidence from Norway of this in the timing of the first but not the second birth (Lyngstad & Prskawetz, 2010). Such interaction may, in theory, make ordinary or twin siblings more or less similar to each other (Kohler et al., 2011). This, in turn, could potentially have influenced the analyses of this study at least by influencing the selection of the sibling FE analytical sample or the fraction of covariance attributable to genetic or environmental factors in the behavioural-genetics analysis. If the siblings influenced each other positively it would decrease the proportion of the population sample analysed in the FE model and increase the amount of attribution to underlying genetic or environmental influences shared by twins in the behavioural-genetics analysis.

A further criticism concerns the assessment of age- and parity-specific differences. As shown in this and previous studies, the association between education and fertility varies by age and parity. Analysing the lifetime number of children in regression models as the main fertility outcome therefore gives a somewhat simplistic picture of the patterns over the life course, and the analysis is essentially not dynamic. Given the particular interest in sibling comparisons relying on within-family variation and the fact that the study is based on older birth cohorts, the analysis of a summary indicator of fertility could be considered justified.

6.3 CONCLUSIONS

The first aim in this thesis was to describe fertility patterns by age, education and early characteristics, particularly among men. A further aim was to assess the potential individual-level mechanisms and the contributions of underlying environmental and genetic sources of variance behind educational differences in lifetime fertility. High-quality Finnish data sets on families and twins, covering female and male cohorts born in the 1940s and 1950s, were used in pursuance of these aims. In conclusion, first births and young-age fertility contributed considerably to diverging patterns in lifetime fertility between Finnish men and women born in 1940-50: the more highly educated women had fewer and the men correspondingly more children in their lifetime. Men and women were more similar in terms of fertility of higher parities and at higher ages: those educated to the higher level had higher fertility in their late 20s and thereafter.

As shown in previous studies, women with higher levels of education do not necessarily have fewer children after the first one. Among the men, education and other socioeconomic resources in adulthood differentiated the groups less with regard to higher-parity fertility than to first births. It seems that socioeconomic factors overall may have more influence on having the first child than on fertility thereafter. Apart from the strong connection between economic resources and having a first child, this result reflects a close relationship between union formation and first-child fertility. As discussed previously, women may prefer men with more economic resources and better employment prospects as partners and potential fathers of their children. The study findings also revealed educational differences among men in the variation in the quantum and tempo of fertility: more variable fertility characterised the life courses of those with a relatively low level of education. This may indicate less planning or more unexpected events among these educational groups. Despite their later start, the more-highly-educated men accumulated more children in their lifetimes within a shorter age-span.

The results of this study, based on the Finnish cohort born in 1940-50, indicate that the role of early-life characteristics in fertility depends on gender. Whereas women from an affluent background accumulated fewer children in their lives, the opposite was generally the case for men. The observed early characteristics explained educational differences in female lifetime fertility to a moderate degree, whereas no such explanatory role was evident among the men. Analyses controlling for unobserved characteristics shared by siblings supported this interpretation. These results point to the relevance of causal mechanisms in adulthood in explaining the educational differences among men in particular. In line with economic theory, mechanisms related to labour-market attachment appear to be important for the process of having a first child, whereas such mechanisms may matter less in the fertility of higher parities.

In line with previous results, the behavioural-genetics analysis based on the Finnish twin cohort born in 1950-57 indicated that the lifetime chance of having a first child is influenced by family-based genetic factors in both genders. The finding of most interest, however, was that underlying family-based genetic factors could influence the association with the level of education, affecting each outcome either directly or indirectly through the other. Corresponding results on the age at having the first child imply that underlying environmental effects are more important for this outcome and its association with education. Given the results of this study based on the population sample of Finnish cohorts born in 1940-50, it appears that the association between education and the chance of having a first child could be influenced to a larger extent by family-based genetic effects on fertility that operate indirectly through education, rather than directly on both outcomes.

Finnish women born in the 1940s did not have the opportunity to benefit as much from the increasing public support of families from the 1970s onwards as the younger female cohorts did. This is likely to be reflected in the less-negative educational differentials among women born later, who faced lower opportunity costs of motherhood (Ilmakunnas, 1994; Ruokolainen & Notkola, 2007). At the same time, even highly educated men born in the 1940s had higher lifetime fertility. The roles of men and women could be viewed as somewhat inter-dependent: the compatibility of work and family life that men enjoy is partly responsible for the incompatibility among women (Bernhardt, 1993; Goldscheider et al., 2015). More recently, gender equality in terms of caregiving has also taken a step forward, highly educated men being at the forefront of this change (Lammi-Taskula, 2007). Welfare-state policies supporting gender equality may enable both women and men to combine family and working life, encouraging fertility in particular among highly educated groups (Cherlin, 2016; Esping-Andersen, 2009).

The tendency remains in more recent Finish cohorts for men with lower levels of education to remain childless (Väestöntutkimuslaitos, 2015). The high incidence of childlessness among groups of men and increasingly also women (Andersson et al., 2009) with a low level of education raises another type of concern: remaining childless may challenge the wellbeing of those with limited resources. A large proportion of childless Finnish men and women born in the 1940s remained unmarried over their adult life, the tendency in men being particularly strong among the less-highly educated. Childlessness and living alone may have negative consequences on wellbeing in the long term, for instance, because of a lack of social support at older ages (Keizer, Dykstra, & Poortman, 2010; Kendig, Dykstra, van Gaalen, & Melkas, 2007; Umberson, Pudrovska, & Reczek, 2010). It follows that the higher frequency of lifetime childlessness among less-highly educated men may contribute to population-level differentials in wellbeing.

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